Volume 26 SEPTEMBER, 1952 Number 5

QE 701 T8

JOURNAL OF PALEONTOLOGY

A publication of The Society of Economic Paleontologists and Mineralogists *and* The Paleontological Society *with the generous support and cooperation of* The American Association of Petroleum Geologists *and* The Geological Society of America

UNIVERSITY OF MICHIGAN SEP 16 1952 MUSEUMS LIBRARY

CONTENTS

Some new Pelecypoda from the Glen Rose formation of Texas ..... *Marion Whitney* 697

Middle Eocene Foraminifera from Peñon Seep, Matanzas Province, Cuba ..... *W. Storrs Cole* and *Donald W. Gravell* 708

Holothuroidea from the Iowa Devonian ..... *Ward R. Martin* 728

Fossil nautiloid faunas from Australia ..... *Curt Teichert* and *Brian F. Glenister* 730

An aglaspid merostome from the Upper Ordovician of Ohio ..... *Kenneth E. Caster* and *William B. Macke* 753

A new Upper Cretaceous ammonite genus from Wyoming and Utah ..... *W. A. Cobban* 758

Two new species of ostracods from the Genshaw formation (Middle Devonian) of Michigan ..... *Robert V. Kesling* and *Norman L. Tabor* 761

Dimorphism in Devonian hollinid ostracods of North America ..... *Robert V. Kesling* 764

Doubling in size of ostracod carapaces in each molt stage ..... *Robert V. Kesling* 772

A *Manticoceras* from Missouri ..... *A. G. Unklesbay* 781

The arms of *Perimestocrinus* ..... *Harrell L. Strimple* 784

Schizocoralla from the Ordovician of Manitoba ..... *Edward L. Leith* 789

Cephalic sutures in the Upper Cambrian trilobite *Entomaspis* ..... *Franco Rasetti* 797

Revision of the pelecypod genus *Echinochama* ..... *David Nicol* 803

Redescription of two gastropods named by Cragin ..... *Keith Young* 818

Structure and paleontological significance of the oral apparatus of the foraminiferoid *Gromia oviformis* Dujardin ..... *Zach M. Arnold* 829

Revision of the Pennsylvanian and Permian footprints *Limnopus*, *Allopus* and *Baropus* ..... *Donald Baird* 832

Species of the Silurian rugose coral *Tryplasma* from North America ..... *Erwin C. Stumm* 841

Not *Astrodapsis* in Japan ..... *J. Wyatt Durham* 844

A classification of the Triassic ammonoids ..... *Bernhard Kummel* 847

PALEONTOLOGICAL NOTES 854

NOMENCLATURAL NOTES 859

REVIEWS 862

SOCIETY RECORDS AND ACTIVITIES 864

EDITORS

GROVER E. MURRAY and L. J. WILBERT, JR., for The Society of Economic Paleontologists and Mineralogists.

A. SCOTT WARTHIN, JR., for The Paleontological Society.

THE JOURNAL OF PALEONTOLOGY is published bi-monthly. The numbers issued in January, May, and September are sponsored by The Paleontological Society in Cooperation with The Geological Society of America; those issued in March, July, and November are sponsored by The Society of Economic Paleontologists and Mineralogists in cooperation with The American Association of Petroleum Geologists.

The subscription price of the JOURNAL OF PALEONTOLOGY is $10.00 per year prepaid to addresses in the United States.

Single numbers, $2.00 each to nonmembers, $1.50 to members.

Postage is charged extra for all other countries in the Postal Union, 40 cents on annual subscriptions (total $10.40).

THE JOURNAL will furnish reprints at cost. Orders should accompany manuscript.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and nonreceipt of preceding numbers should be addressed to Society of Economic Paleontologists and Mineralogists, P. O. Box 979, Tulsa 1, Oklahoma. Claims for nonreceipt of preceding numbers must be sent in within three months of the date of publication in order to be filled gratis. Communications in regard to advertising should be addressed to T. H. Philpott, The Carter Oil Company, P.O. Box 1739, Shreveport, La.

Communications in regard to manuscripts or purely editorial matters should be addressed to Grover E. Murray or L. J. Wilbert, Jr., School of Geology, Louisiana State University, Baton Rouge 3, Louisiana or to A. Scott Warthin, Jr., Vassar College, Poughkeepsie, N.Y.

Contributors are requested to instruct their photographers to illuminate fossils from the upper left side, the conventional manner. Plates normally should be arranged for publication at the size of 5¼ by 7½ inches, exclusive of margins, heading, and title. Printed numerals of standard size and form may be obtained free from either editor. When requesting them state number of plates and the dimensions of each plate.

A statement of style, form and procedure for the JOURNAL, published in Volume 25, no. 5, is available in reprint form on request to either editor.

Entered as second-class matter at the Post Office at Tulsa 1, Oklahoma, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R. authorized April 3, 1935.

Additional entry as second-class matter at the Post Office at Menasha, Wis.

Printed in U.S.A.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

JOURNAL OF PALEONTOLOGY

A publication of THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS *and* THE PALEONTOLOGICAL SOCIETY *with the generous support and cooperation of* THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS *and* THE GEOLOGICAL SOCIETY OF AMERICA

VOLUME 26 | SEPTEMBER, 1952 | NUMBER 5

SOME NEW PELECYPODA FROM THE GLEN ROSE FORMATION OF TEXAS

MARION WHITNEY
Austin, Texas

ABSTRACT—Descriptions are given of several new species of Pelecypoda of the Glen Rose formation of central Texas. Three of these are reef-formers which developed some spectacular reefs, chiefly in the massive limestone members of the lower Glen Rose.

THIS paper deals chiefly with fauna of the lower Glen Rose formation of the Cretaceous of central Texas, but contains some species from the upper Glen Rose. The lower Glen Rose contains a rich fauna, among which are several reef-formers previously undescribed. There are large rudistid, *Toucasia*, and *Monopleura* reefs in the massive limestone beds. Although the fossils are extremely numerous, it is difficult to obtain good specimens from the indurated limestone. In a few places erosion has done an excellent job of dissecting them into cross and longitudinal sections. A few well preserved specimens from the reefs have been collected by Dr. F. L. Whitney. Among these are four new species, three of which are described in this paper. The fourth is a *Monopleura* unlike either *M. marcida* White or *M. subtriquetra* Roemer, which occur in these reefs, but the specimens are not well enough preserved to describe adequately. Whereas the two known species of *Monopleura* from the Glen Rose are twisted, the undescribed species is straight. The writer has seen it in enormous numbers in a reef on Bee Creek, Travis County, Texas, where it occurs usually as badly eroded casts or gives evidence of its former existence by numerous circular holes.

Toucasia texana (Roemer), originally described by Roemer (1852, p. 41) as *Caprotina texana* was generally believed to have been collected by him from the Edwards limestone, but there is a possibility that he may also have collected specimens from the Glen Rose because he mentions that they were found on the road from New Braunfels to Fredericksburg. He had to travel over much Glen Rose country as well as Edwards to make the journey from one town to the other and could well have found this species in both formations, for the Glen Rose specimens agree in all respects with those of the Edwards limestone, and the massive reef beds of the Glen Rose are so similar in appearance to the Edwards that they have frequently been mistaken for Edwards. The following are some of the localities in which Dr. F. L. Whitney found *Toucasia texana:* along the bluff on the Guadalupe River, 4 miles below Hancock, Texas; 1 mile north of Cranes Mill, Comal County, Texas; and near Wimberly, Hays County, Texas.

In addition to *Toucasia texana*, Dr. Whitney collected two new species of

Toucasia and the *Coalcomana* described here. The latter occurs in some spectacular reefs. There is a strong resemblance of the specimens at hand to the genus *Immanitas* Palmer, but the type specimen was seen by Henry J. MacGillavry, specialist in rudistids, and identified as *Coalcomana*.

This paper also contains descriptions of several other pelecypods of the lower Glen Rose, including some new species of *Trigonia*, which were first named and described by Arno Wendler in an unpublished thesis. These specimens were also collected by Dr. F. L. Whitney. The writer has retained the names given the species by Wendler but redescribed the forms.

The type specimens are located in the Department of Geology, The University of Texas, Austin, Texas.

SYSTEMATIC DESCRIPTIONS

Superfamily CHAMACEA Geinitz
Family DICERATIDAE Dall
Genus TOUCASIA Munier-Chalmas

TOUCASIA HANCOCKENSIS Whitney, n. sp.
Plate 86, figures 1–3

Shell small to medium in size, very inequivalve. Beaks twisted and somewhat elevated. Left valve large, flattened and concave on the attachment side; rounded inflated and deeply grooved with two long, curved, narrow, grooves on the opposite side. The edge of the shell is sharply carinate where the original shell is preserved, but rounded in the cast. The right valve is smaller than the left valve, but similar in shape. The superior valve is not truly operculiform because it attains considerable thickness and width. It is flattened and concave on the attachment side; rounded and inflated on the opposite side. Here it is flush with inferior valve or slightly depressed, but never jutting above it as does *Toucasia texana*. The edge is carinate. On the attachment side the superior valve is plainly visible. In some specimens it is practically flush with the surface of the inferior valve, but in others it is at an angle of 30° to 40° to the inferior valve. The surface of the shell is rough and corrugated where the outside layer is preserved, but is smooth where it is not preserved. Long, curved lines cross the shell. There seem to be at least two thin layers of shell material present, but in some places a third layer is visible. Along the keel the shell material is thicker than elsewhere. The lower layer is translucent while the upper layers seem to be opaque.

Toucasia hancockensis bears some resemblance to *T. texana* but differs in several respects. The beaks are more elevated, giving the shell a more twisted appearance. The superior valve differs in size, shape and position. It is larger, broader and is practically flush with both sides of the inferior valve. It is always visible from the attachment side even when it stands at an angle to the left valve, and its width increases the size of the shell over that of *T. texana*. Also *T. hancockensis* seems to be more inflated. It resembles *T. carinata* Matheron in the shape and placement of the superior valve and in the general shape of the shell. It differs, however, in being much narrower than *T. carinata*.

Occurrence.—Bluff on Guadalupe River 4 miles below Hancock, Texas. Upper Glen Rose.

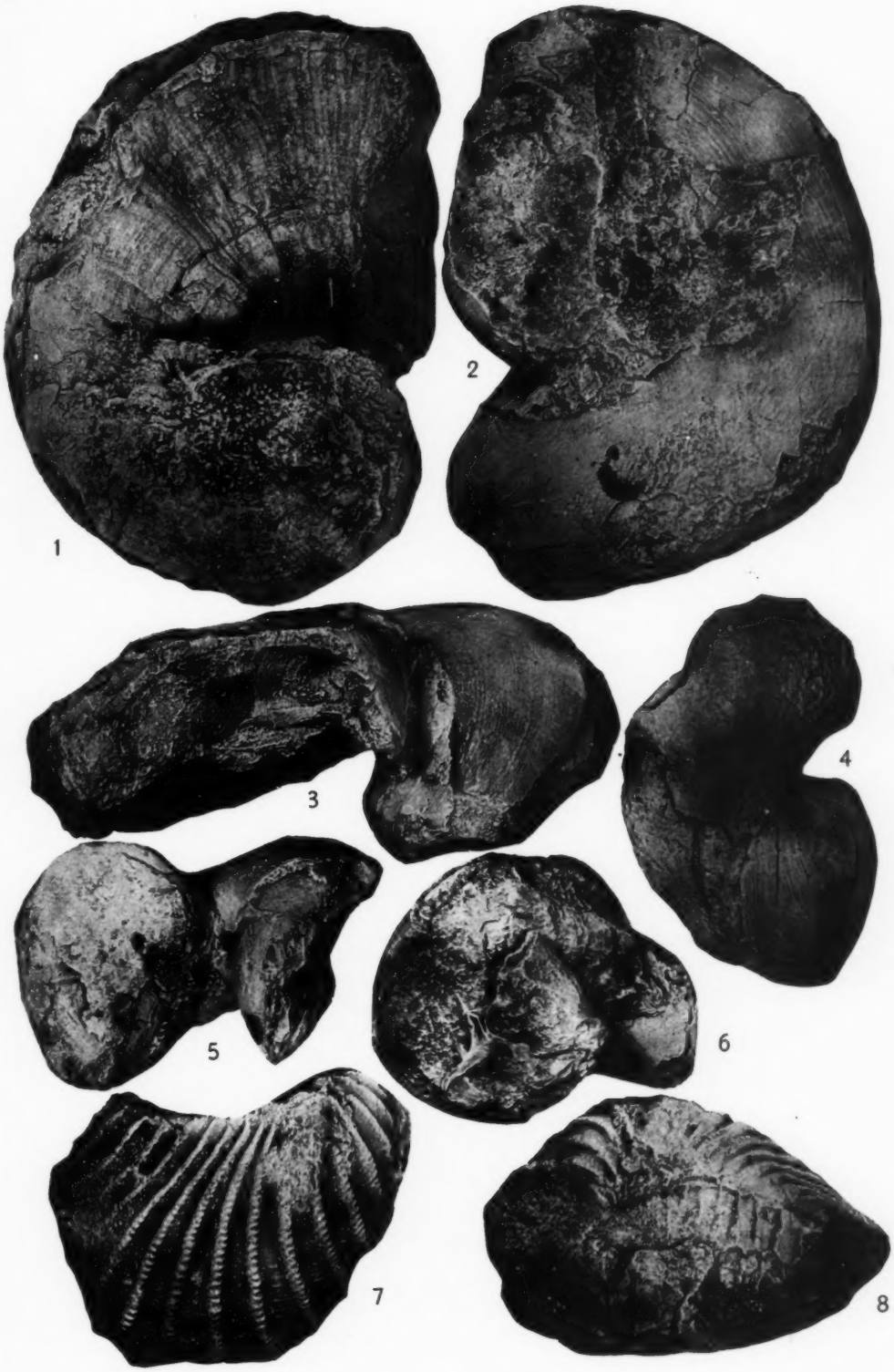
TOUCASIA PSEUDOPATAGIATA Whitney, n.sp.
Plate 86, figures 4–6

Shell moderately small, greatly elevated and twisted, narrow and inequivalve. Left valve larger, flattened, and concave on the attachment side, rounded and slightly inflated on the opposite side, carinate, contorted, beak highly twisted and elevated. Right valve smaller, somewhat operculiform but quite broad on the anterior end and narrowed at the posterior end. The beaks are twisted but compressed, and the flattened side is wide and concave. The right valve drops sharply away from the

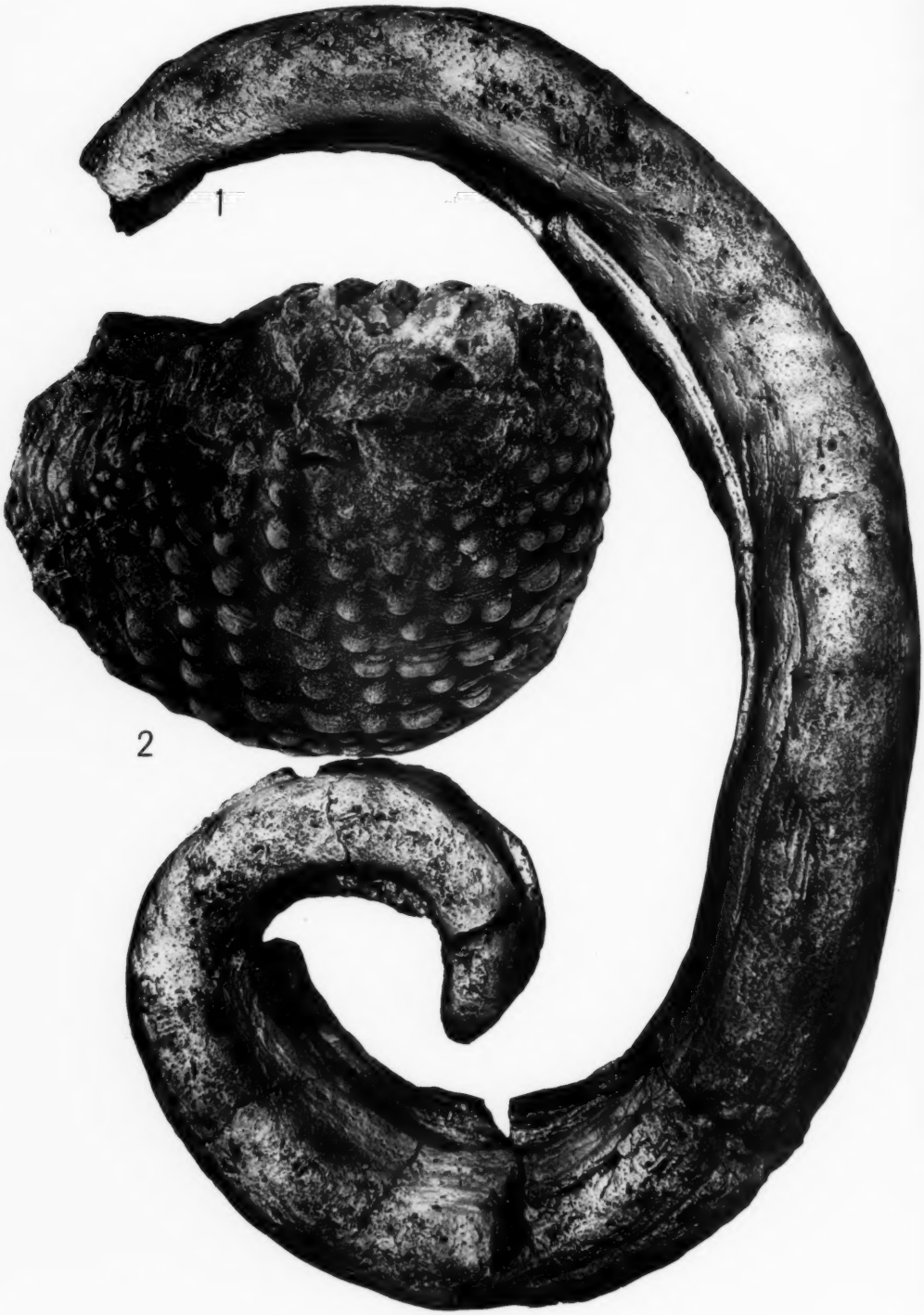
---

EXPLANATION OF PLATE 86

FIGS. *1–3*—*Toucasia hancockensis* Whitney n. sp., ×1. *1*, view of large valve on attachment side. *2*, view of opposite side of large valve. *3*, view of small valve. (p. 698)
4–6—*Toucasia pseudopatagiata* Whitney n. sp., ×1. *4*, view showing both valves. *5*, view of small valve. *6*, view of attachment side. (p. 698)
7–8—*Trigonia whitneyi* Whitney n. sp., ×1. *7*, lateral view, *8*, dorsal view. (p. 701)



Whitney, Texas Glen Rose Pelecypoda



Whitney, Texas Glen Rose Pelecypoda

inferior valve at an angle of 90° when the shell is viewed from the attachment side, and it can not be seen in this view. On the opposite side it rises obliquely to a considerable height above the inferior valve. The shell material appears to be thin except along the keel and consists of two layers. The outer layer is corrugated, while the inner layer is smooth. Long, oblique lines cover the surface.

Toucasia pseudopatagiata is probably an ancestor of *T. patagiata*, for it has a similar form but is not so twisted nor so high. The beaks are not so elevated and the slopes are not so steep along the sides. The upper valve differs in shape. It is narrower, particularly on the posterior and anterior ends. The beak of the right valve in *T. patagiata* is so large that it coils up over the upper portion of the inferior valve, which gives it quite a different appearance from *T. pseudopatagiata* in this portion, but the rest of the shell is quite similar to it in general appearance.

Type locality.—About 30 feet above the *Salenia texana* horizon near the base of Shovel Mountain near Cypress Creek in Blanco County, Texas. Since the *Salenia texana* horizon has been found by Dr. F. L. Whitney to be just below the boundary between upper and lower Glen Rose, *T. pseudopatagiata* is found in the upper Glen Rose.

Family Caprinidae d'Orbigny
Genus Coalcomana Harris and Hodson
Coalcomana texana Whitney, n. sp.
Plate 87, figure 1

Cast very long, slender, arcuate, or loosely coiled. The valves are not quite equal in length, but they are similar in form. In cross section they are roughly quadrangular. Extending the full length of the cast there is a ridge bounded on one side by a very deep, narrow groove and two smaller ridges and on the other side by a smaller groove. On the opposite side of the shell there is a long, sinuous groove extending from beak to beak. The shell structure is eroded, but small, striated ridges appear all over the surface and probably correspond to tubular structure of the interior. Nothing is known of the dental apparatus. In numerous places it forms reefs. One of the finest reefs is just above Pleasant Valley crossing of the Blanco River, Hays County, Texas. Here cross sections produced by erosion reveal the many rows of canals of the interior.

Dimensions.—Length about 550 mm., width about 50 mm.

Occurrence.—About 234 feet above the base of the Glen Rose, 3 miles north of Hancock, Texas, about one-half mile west of Fischer Store-Hancock road: also found on Highway 46 about 2 miles west of Smithson's Valley, Comal County, Texas. Lower Glen Rose.

Type Locality.—Three miles north of Hancock, Texas, about one-half mile west of Fischer Store-Hancock road.

Superfamily Arcacea Deshayes
Family Arcidae Lamarck
Genus Arca Lamarck
Arca texana (Roemer)
Plate 88, figures 8, 9

Cypricardia texana Roemer 1852, Die Kreidebildungen von Texas, p. 50, pl. 6, fig. 1.
Cypricardia texana Adkins, Handbook of Cretaceous Fossils, Univ. Texas Bull. 2838, 1928, p. 162.

Cast elongate, trapezoid, small, equivalve, inequilateral. Umbones anterior, small, rounded on the anterior side, angular and truncated on the posterior side. Beaks separated and only slightly incurved and acuminate. Cardinal area lanceolate, having its greatest expanse on the posterior side. It is distinctly separated from the postumbonal slope by the ligamentary grooves which come together at the hinge line, forming V-shaped patterns. The most posterior groove is the deepest and longest, while the grooves on the anterior side of the cardinal area are shortest and faintest. The hinge is long and straight. Faint indications of the bottoms of the taxodont teeth at the ends of the ligamentary grooves can be seen on most of the specimens at hand. The narrowly rounded anterior margin joins the hinge line with a rounded obtuse angle and

Explanation of Plate 87

Fig. *1*—*Coalcomana texana* Whitney n. sp. ×⅔. (p. 699)
2—*Trigonia gordoni* Whitney n. sp. ×⅔. (p. 702)

continues its curvature into the long, arcuate ventral margin. The angle between the ventral margin and the posterior margin is quite sharp and acute. The posterior margin is straight, sloping and carinate. The postumbonal slopes are wide, concave and together form a heart-shaped area bounded by the long, arcuate and decidedly carinate umbonal ridges which extend from the points of the beaks to the acute posteroventral angle.

The shell tapers gradually from about the middle to the posteroventral angle and tapers more abruptly to the anterior margin. The greatest diameter is on the umbonal ridge slightly posterior and dorsal to the center of the shell. The greatest height is at the beaks. At the posterior end of the umbonal margin the shell is only slightly greater in height than at the anterior end. The sides are not inflated, only gently convex.

The ornamentation consists of irregularly spaced growth lines and very fine radial striae which are close together and, on the postumbonal slope, are distinguished from the ligamentary grooves only by their smaller size and the deep ligamentary groove which separates the two series of lines. The pallial line is distinct and entire.

Roemer described this species as *Cypricardia texana* and mentions that it might be an *Arca*. Apparently his specimens did not show the ligamentary grooves and the impressions of the taxodont teeth which certainly place it in the family Arcidae and most likely in the genus *Arca*.

Dimensions.—Height 12 mm., length 20 mm., width 1 cm.

Occurrence.—One mile east of Bandera, Texas, *Salenia texana* horizon, lower Glen Rose.

ARCA SIMONDSI Whitney, n. sp.
Plate 88, figure 1; plate 89, figure 1

Cast very large, elongate, slender, equivalve, inequilateral. Beaks very high and narrow, almost terminal, slightly incurved, broad and blunt at the tips, slightly inflated. Cardinal area low, broad, deeply marked with ligamental grooves. Hinge line long, straight, slightly arched, marked throughout its entire extent by zigzag lines which are the impressions of the lower side of the articulated taxodont teeth. The hinge extends along almost the entire length of the cardinal margin and is about 45 mm. long. The anterior margin is short, produced slightly, fairly thin and rounded. The ventral margin is very long, nearly straight or slightly arched in some specimens, very thin and carinate. The posterior margin is long, sloping, produced, rounded below, straight above and appears to have a depression just below the muscle scar. It likewise is thin. The ends of the shell are thin and somewhat attenuated. The lower portion of the sides is compressed. The upper portion is quite inflated and the greatest thickness is attained on the umbones above the middle of the shell. The postumbonal ridges are long, oblique and gently concave. The postumbonal slope is long, quite wide, convex above, concave below, especially at the large, circular, depressed muscle scars. Posterior to the center of the scars there is an arcuate ridge which bends outward and extends across the scars. The anterior umbonal ridge is nearly vertical, but becomes slightly concave near its lower portion where it bends outward to the anterior margin. The anterior muscle scars are large, subcircular, raised on the anterior side and deeply depressed on the posterior side. They are situated at the junction of the cardinal and anterior margins. The pallial line is long, entire and broadly curved at the posterior end and meets the muscle scars in the center of their ventral sides. The sides of the shell are marked by very irregular, high, oblique lines. One line on each side extends down obliquely from the upper portion of the umbones and appears like a ridge.

Arca simondsi was first regarded as a *Cucullaea* because of its general shape, but the extremely long hinge line with the zigzag teeth throughout its whole length and the lack of internal plait grooves distinguish it from *Cucullaea*.

Dimensions.—Height 65 mm., length about 100 mm., width 55 mm.

Occurrence.—Bandera County, on road between Bluff and Medina; also on Guadalupe River near Cranes Mill, Comal County, Texas.

Type locality.—Bandera County, on road between Bluff and Medina. Lower Glen Rose.

Superfamily TRIGONIACEA Bonn
Family TRIGONIIDAE Lamarck
Genus TRIGONIA Bruguiére
TRIGONIA WENDLERI Whitney, n. sp.
Plate 88, figure 2

Trigonia aliformis ROEMER, Texas, p. 404, 1849.
Trigonia crenulata LAMARCK. Roemer, Die Kreidebildungen von Texas, p. 51, pl. 7, fig. 6. 1852.
Trigonia crenulata SHUMARD, Expl. Red River, La., by R. B. Marcy, p. 206, pl. 4, fig. 1. Washington, 1853, B. F. Shumard.
Trigonia crenulata HILL, 1893, Washington Biol. Proc., vol. 8, p. 27, pl. 3, fig. 4.
Trigonia crenulata ADKINS, Handbook of Cretaceous Fossils, Univ. Texas Bull. 2838, 1928, p. 120.

Cast moderately small, subtriangular, equivalve, inequilateral. Beaks anterior, quite terminal, blunt, slightly distant, directed posteriorly, erect. Anterior margin quite high and obliquely truncate. Anterior end very broad, tapering abruptly to the keel-like margin. Ventral margin very broadly curved, swinging downward abruptly on the anterior end and rising gradually to the small, attenuated posterior margin which also is obliquely truncated, but very much smaller and thinner than the anterior end. The posterior cardinal margin is high, carinate and only very slightly sloping. Umbonal ridge long, arcuate, bending downward in the middle but rising to the posterior end of the shell. Postumbonal slopes wide, concave, broken by carinae which run from the beaks down to the sharply carinate posterior portion of the cardinal margin. The posterior muscle scars high on the postumbonal slope, slightly posterior to the center of the cardinal margin. They are subcircular in shape and raised. The surface of the shell is ornamented with 20 radiating, crenulate ribs. These ribs swing posteriorly near the cardinal margin, but curve so that they are directed anteriorly along the ventral margin. They are quite high and close together near the cardinal margin. Near the ventral margin they spread out considerably and indent the margin. The crenulations are quite coarse and rounded, evenly spaced. On the postumbonal slope the markings are complicated and very poorly preserved on all the specimens at hand. On the outer slope the ribs appear to bend slightly to the posterior and join, at the carina, other ribs which proceed anteriorly to the cardinal margin.

Roemer called this species *Trigonia crenulata*. In comparing his picture and the specimens at hand with d'Orbigny's figure of *T. crenula* several noticeable differences have been observed.[1] First of all there are many more ribs on *T. crenulata* and the crenulations seem to be more numerous. The postumbonal margin is more sloping and much lower than the beaks at the posterior end than is that of *T. wendleri*. The posterior portion of the postumbonal slope is wider in *T. crenulata* and the lower exterior portion of the postumbonal slope is not marked by ribs as in *T. wendleri*. Also the posterior muscle scar differs in shape and position. That of *T. crenulata* is more elongate, truncate on the anterior end, pointed on the posterior end and is directed down the postumbonal slope, whereas that of *T. wendleri* is subcircular and directed obliquely across the umbonal slope.

Dimensions.—Height 25 mm., length 40 mm., width 21 mm. The specimen measured was small but in a better state of preservation than the larger specimens.

Type locality.—Near Lohmann Ford of Colorado River, Travis County, Texas. *Salenia texana* horizon of lower Glen Rose.

TRIGONIA WHITNEYI Whitney, n. sp.
Plate 86, figures 7, 8

Cast moderately small, subtriangular, equivalve, inequilateral, ventricose. Beaks small, close together, very close to the anterior end, directed posteriorly, incurved and pointed. Posterior cardinal margin long and arcuate, high on the anterior end, sagged in the middle and raised at the posterior end, zigzag at the carination. Anterior margin very truncate, oblique and quite high. Ventral margin broadly rounded, rising gradually to the narrow, truncated posterior end. The sides are marked with about 20 high, rounded, narrow, crenulate ribs separated by wide concave grooves. The ribs swing posteriorly near the umbonal slope but bend gently toward the anterior in the ventral region. The crenulations are

[1] d'Orbigny, A., Paléontologie française; Terrains crétacés, vol. 3, p. 151, pl. 295. 1843–1847.

fairly coarse, regular, and cross the ribs as short, rounded ridges, which give the ribs the appearance of being ropes that extend down over the sides of the shell. Between the ribs can be seen irregular lines of growth. The outer edge of the umbonal slope is rounded and crossed by numerous short, narrow, vertical ridges, usually three to four between each rib. The postumbonal slope is trough-like, concave in the middle, rising at both ends and along the sides. Crossing this are sharp, narrow, straight ridges separated by concave troughs four to five times as wide as the ridges. The troughs are about equal in width to the dorsal ends of the troughs between the radial ribs which cover the sides, but the latter widen greatly in the ventral portion. The postumbonal ridges from both sides of the shell alternate along the umbonal margin and cause the zigzag appearance of the margin. There seems to be no wide exterior umbonal slope area as in other species, but the rounded outer margin marked by fine ridges and often accompanied by a narrow parallel trough on its inner edge takes the place of the wide exterior area normally present in *Trigonia*.

Trigonia whitneyi bears a striking resemblance to *T. limbata* d'Orbigny (loc. cit., pl. 298), but differs in having fewer ribs, more marked crenulations and a different type of marking on the postumbonal slope.

Trigonia whitneyi was described and named by Arno Wendler in an unpublished paper.

Dimensions.—Height about 35 mm., length about 55 mm., and width about 29 mm. No exact dimensions can be given because of the state of preservation and the fact that most of the specimens are at least partially imbedded in sandstone.

Type locality.—Lower Glen Rose at B. M. 845, Cow Creek, Burnet County, Texas.

TRIGONIA GORDONI Whitney, n. sp.
Plate 87, figure 2

Cast large, subtriangular, equivalve, inequilateral, quite compressed. Beaks terminal, small, blunt, tangent. Posterior cardinal margin too poorly preserved in the specimens at hand to characterize beyond the fact that it is sloping and very long. The anterior margin is high, broadly rounded, truncated. Anterior end quite thick but somewhat thinner than the middle of the shell. The ventral margin is long, arcuate, and thin. The posterior margin is fairly wide and bluntly rounded. The posterior end is quite thin. The sides of the shell are quite compressed and are only gently convex. They are decorated with long curving rows of large, rounded, circular or elliptical tubercles. On the wide postumbonal slope these tubercles seem to be small and scattered. In the central portion of the sides the tubercles are generally circular, but a few lengthen vertically. They are irregular in size and somewhat irregular in position. Along the margins they are greatly elongated transversely, crowded, and very irregular in size and position. Between the tubercles are fine, irregular, imbricate, contorted lines of growth.

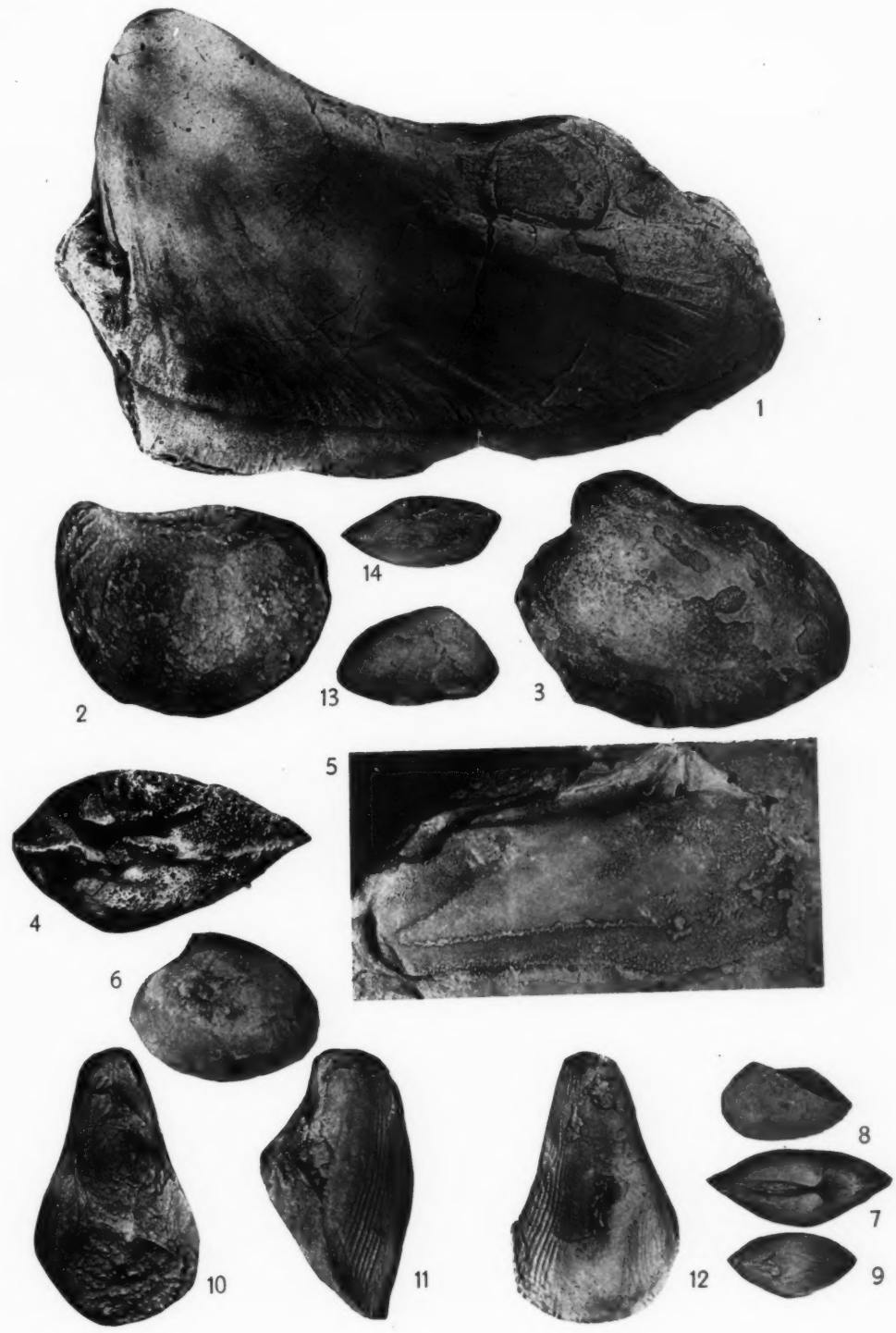
Trigonia gordoni has a great deal in common with *T. daedala* Park but differs in shape and does not appear to have the nodular tubercles on the area. It is possible that *T. gordoni* is closely related to *T. taffi* Cragin, for it seems to fit the description of *T. taffi* in many respects, but since Cragin did not figure it, the relationship can not definitely be established.

Trigonia gordoni was named and described by Arno Wendler in an unpublished paper.

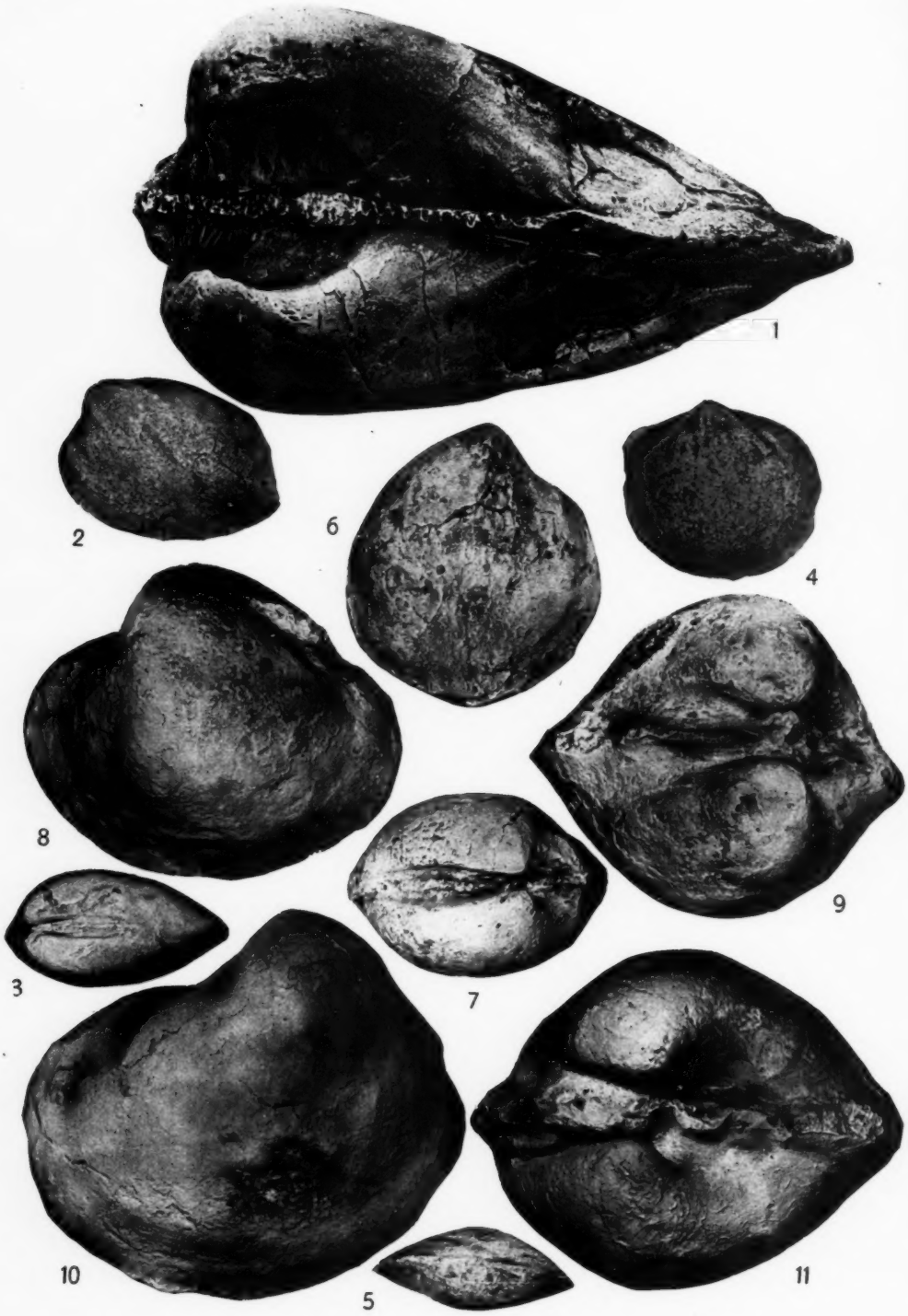
Dimensions.—Height about 75 mm., length 95 mm., width 37 mm.

EXPLANATION OF PLATE 88

FIG. *1*—*Arca simondsi* Whitney n. sp. ×1, lateral view. (p. 700)
2—*Trigonia wendleri* Whitney n. sp. ×1, lateral view. (p. 701)
3–4—*Cardita staffordi* Whitney n. sp. ×1. *3*, lateral view. *4*, dorsal view. (p. 704)
5—*Crassatellites eifleri* Whitney n. sp. ×1, lateral view. (p. 704)
6–7—*Tapes bakeri* Whitney n. sp. ×1. *6*, lateral view, *7*, dorsal view. (p. 705)
8–9—*Arca texana* (Roemer) ×1. *8*, lateral view, *9*, dorsal view. (p. 699)
10–12—*Spondylus olsenae* Whitney n. sp. ×1. *10*, left valve, *11*, side view of both valves, *12*, right valve. (p. 703)
13–14—*Cypricardia pelletae* Whitney n. sp. ×1. *13*, lateral view, *14*, dorsal view. (p. 703)



Whitney, Texas Glen Rose Pelecypoda



Whitney, Texas Glen Rose Pelecypoda

Type locality.—Lower Glen Rose at B. M. 845, Cow Creek, Burnet County, Texas.

Superfamily PECTINACEA Reeve
Family SPONDYLIDAE Fleming
Genus SPONDYLUS Linnaeus
SPONDYLUS OLSENAE Whitney, n. sp.
Plate 88, figures 10–12

Shell small, narrow, conical, very inequivalve, almost equilateral. The right valve is greatly produced above the left valve. The beak is high, blunt, and rounded. The entire central portion of the right valve is very elevated and rounded. The flanks along the central ridge are flattened and steeply sloping toward the sides. The upper portion of the right valve is very narrow, but the lower portion is quite expanded. The hinge area is large, triangular, and slightly depressed. The whole shell is covered with small, fairly regular, radial ribs which are close together and covered with small spines. The left valve is compressed and almost flat. The beak is slightly rounded and convex, while the ventral margin is somewhat concave to fit into the central ridge on the opposite valve. The inequality in the size of the valves and the flatness of the left valve cause it to have the appearance of an operculum. The wings are very small. The sides are gently rounded, long, and crenulate. The shell is thin along the margins, but elsewhere it is quite thickened. Only one specimen has been found.

Spondylus olsenae bears some resemblance to *S. coquandianus* d'Orbigny in its narrow, produced right valve, but it is not so greatly produced and the left valve is much more compressed.

Dimensions.—Height 36 mm., length 22 mm., width taken at the apex of the left valve 21 mm.

Type locality.—Found in clay beds about 275 feet above the base of the Glen Rose on the road between Fischer Store and Hancock, Texas, near the latter town.

Superfamily CYPRICARDIACEA Dall
Family PLEUROPHORIDAE Dall
Genus CYPRICARDIA Lamarck
CYPRICARDIA PELLETAE Whitney, n. sp.
Plate 88, figures 13, 14

Cast small, equivalve, inequilateral, elongate, four-sided. Beaks anterior, small, very close together, rounded at the points. Umbonal margin sloping, straight, flattened. Anterior margin eroded, but appears to be very sloping in the upper portion and narrowly rounded at the lower end. The ventral margin is long and arcuate. The posterior margin is slightly curved, carinate and sloping. The angle between the ventral and posterior sides is acute but broadly rounded. The umbonal ridge is long, slightly arcuate, broadly rounded and low. It becomes less and less distinct as it proceeds obliquely downward toward the posteroventral angle. Very close to the beaks it is faintly carinate. The postumbonal slopes are narrow, slightly concave and together are roughly heart-shaped. The sides are flattened and only slightly convex. Down the middle of the shell from the umbones to the ventral margin there is a broad area which appears to be faintly depressed. The greatest width seems to be slightly posterior to the center on the umbonal ridges. The greatest height is at the beaks. At the angle between the posterior and umbonal margins the shell is considerably lower than at the beaks. The sides are lined by a few irregularly spaced concentric growth lines.

Cypricardia pelletae resembles *C. compacta* in many respects but differs from it in having a more rounded umbonal ridge; a more sloping umbonal margin; a more rounded posteroventral angle; less demarcation of the juncture between the umbonal and posterior margins; flatter, narrower sides; possesses the faint depression on the flanks and has a different shaped anterior margin.

Dimensions.—Height 13 mm., length 23 mm., width about 8 mm.

EXPLANATION OF PLATE 89

FIG. *1*—*Arca simondsi* Whitney n. sp. ×1. *1*, dorsal view. (p. 700)
2–3—*Nucula bybeei* Whitney n. sp. ×1. *2*, lateral view, *3*, dorsal view. (p. 704)
4–5—*Lucina (Phacoides) horni* Whitney n. sp. ×1. *4*, lateral view, *5*, dorsal view. (p. 705)
6–7—*Meretrix wellsi* Whitney n. sp. ×1. *6*, lateral view, *7*, dorsal view. (p. 705)
8–9—*Corbis hamiltonae* Whitney n. sp. ×1. *8*, lateral view, *9*, dorsal view. (p. 706)
10–11—*Corbis banderaensis* Whitney n. sp. ×1. *10*, lateral view, *11*, dorsal view. (p. 706)

Type locality.—Basal Glen Rose on Cow Creek, Burnet County, Texas.

Superfamily NUCULACEA
Family NUCULIDAE Adams
Genus NUCULA Lamarck
NUCULA BYBEEI Whitney, n. sp.
Plate 89, figures 2, 3

Cast small, elliptical, equivalve, very inequilateral. Beaks almost terminal, small, directed anteriorly, close together, rounded on the point, continuing the even posterior cardinal margin on the posterior side. The hinge is arcuate; no teeth can be seen. Posterior cardinal margin long, arched, high and presenting no concavity behind the beaks. Anterior cardinal margin concave, short. Anterior end thickened, narrowly rounded. Ventral margin arcuate. The posterior margin seems to have been rounded, but has been eroded in the specimens at hand. It is much higher than the anterior margin. The height of the shell is more than half its length. The highest portion is about in the center of the shell. The sides are moderately inflated and the shell seems to be fairly thick throughout except for the thin posteroventral portion. The greatest thickness is a little above the center of the shell. The pallial line is entire and arcuate. The posterior muscle scars are not apparent on the specimens at hand because of their damaged posteriors. The anterior muscle scars are long, lanceolate, oblique and raised on the posterior side. No ornamentation is shown on the sides of the cast.

Dimensions.—Height 21 mm.; length about 31 mm.; width 15 mm.

Type locality.—One mile east of Bandera, Texas, *Salenia texana* horizon, lower Glen Rose.

Superfamily ASTARTACEA Dall
Family ASTARTIDAE d'Orbigny (emend.)
Genus CRASSATELLITES Krüger
CRASSATELLITES EIFLERI Whitney n. sp.
Plate 88, figure 5

Cast elongate, elliptical, equivalve, very inequilateral, large, compressed. The ventral and posterior cardinal margins are practically parallel. Beaks high, prominent, erect, acuminate. Hinge straight and long. Teeth diverging, large, high, and long; impressions deep and narrow. In the right valve there is a long, thickened lateral tooth, a strong anterior cardinal tooth, a weaker medial tooth, and a long, curved, thin lateral tooth. In the left valve there is no anterior lateral tooth visible. Two cardinal teeth, of which the anterior is the stronger, are present. There also appears to be a posterior lateral tooth. The posterior cardinal margin slopes down abruptly from the beak, flattens out and becomes almost horizontal. The anterior cardinal margin and the anterior and posterior margins of the specimen at hand are imbedded in rock. The ventral margin is gently arcuate. The side of the shell is flattened. The umbonal ridge is wide and rounded. The umbonal slope is quite wide and concave, triangular in outline. The pallial line is elevated, beaded, curving at the anterior end, straight on the ventral side, sharply pointed and acuminate on the posterior end and swings sharply back toward the beaks paralleling the umbonal ridge. The posterior muscle scar is large, transverse, oval, irregular along its borders, depressed posteriorly and ventrally, elevated anteriorly and dorsally, and flattened on the dorsal side where it is in contact with the cardinal margin. The area below the pallial line is flat in the anterior portion but depressed and concave beyond the middle.

Dimensions.—Height 30 mm., length about 70 mm., width 12 mm.

Type locality.—Near the base of the Glen Rose at the big spring on the Guadalupe River, near Cranes Mill, Texas.

Superfamily CARDITACEA Menke
Family CARDITIDAE Gill
Genus CARDITA Bruguiére
CARDITA STAFFORDI Whitney, n. sp.
Plate 88, figures 3, 4

Cast elongate, angular, small, equivalve, inequilateral. Beaks far apart, high, prominent, bluntly pointed, subcentral, directed anteriorly. Hinge with impressions of one cardinal tooth on the right valve and two in the left valve. Posterior cardinal margin short, high, straight. Anterior umbonal margin short, curved and gently sloping. Anterior margin obliquely truncate, short, carinate and denticulate. Ventral margin long, slightly curved, carinate, denticulate. Posterior margin blunt, obliquely truncate,

nearly parallel to the anterior margin which is slightly shorter than the posterior margin. The lower part of the posterior margin is rounded and denticulate, while the upper part is straight. The sides of the shell are quite compressed. The umbonal region is slightly ventricose. The anterior muscle scars are oval, raised and close to the anterior margin. The posterior muscle scars are oval, raised, situated on the postumbonal slope at the angle between the umbonal margin and the posterior margin.

Dimensions.—Height 37 mm., length 47 mm., width 23 mm.

Type locality.—Speck's Crossing of the Guadalupe River, Comal County, Texas; basal Glen Rose.

Superfamily VENERACEA Menke
Family VENERIDAE Leach
Genus MERETRIX Lamarck
MERETRIX WELLSI Whitney, n. sp.
Plate 89, figures 6, 7

Cast rotund, subovate, small, equivalve, inequilateral. Beaks high, slightly subcentral, pointed, incurved, directed anteriorly, close together. Hinge arched, indented with the impressions of cardinal teeth. Posterior cardinal margin convex, arched, long, steep. Anterior cardinal margin short, concave. Anterior, ventral and posterior margins similar, broadly rounded, and presenting a continuous curvature in the shape of a hemisphere. The margins are slightly gaping in the specimen at hand. The pallial line is marked by short, vertical ridges and grooves. The pallial sinus is deep, fairly wide, directed upward, sides converging in a narrowly rounded point at the anterior end. Anterior muscle scar oval, slightly oblique, attenuated, and produced posteriorly for a short distance along the anterior cardinal margin. The scar is marked by coarse, arcuate, vertical lines. The posterior muscle scars are not visible on the specimens at hand. The greatest height is at the beaks and the greatest thickness is slightly above the center of the shell.

Meretrix wellsi differs considerably from *M. hanseni* Whitney and *M. texana* (Conrad) in its shape. Where the two latter species have a long arcuate ventral margin, *M. wellsi* has a short ventral margin equal in length and curvature to the anterior and posterior margins. It also has a much steeper cardinal margin and is higher than long.

Dimensions.—Height 39 mm., length 35 mm., width 25 mm.

Type locality.—Boerne-Bandera road 12 miles from Boerne, Texas. Collected by John W. Wells.

Genus TAPES Megerle
TAPES BAKERI Whitney, n. sp.
Plate 88, figures 6, 7

Cast oval, short, small, thin, equivalve, inequilateral. Beaks high, pointed, incurved, directed anteriorly subcentral, close together. Hinge long curved, appears to have three teeth to each valve. Posterior cardinal margin long and arcuate. Anterior cardinal margin short and narrowly concave. Anterior margin carinate, thin, fairly broadly rounded. Ventral margin quite long, arcuate and curving gently to the anterior and posterior margins. Posterior margin more broadly rounded than the anterior margin. Pallial line depressed, arcuate. Pallial sinus deep, fairly wide, rounded on the anterior end, directed upward. Posterior muscle scar oval, flat. Anterior muscle scar oval, slightly raised on some specimens. Sides smooth, very slightly inflated near the beaks, compressed near the ventral margin. Greatest height at the beaks.

Tapes bakeri resembles *T. decepta* (Hill), but is not so long; is more rounded; has a more arcuate ventral margin, a shorter and more concave anterior cardinal margin, a shorter posterior cardinal margin and is proportionately thicker.

Dimensions.—Height 24 mm., length 28 mm., width 13 mm.

Occurrence.—Abundant throughout the Glen Rose. Found at Bandera, Texas and near Fischer Store, Texas and many other places.

Type locality.—Fischer Store-Crane's Mill road, in road cut one-half mile from Fischer Store.

Superfamily LUCINACEA Anton (emend.)
Family LUCINIDAE Fleming
Genus LUCINA Bruguiére
LUCINA (PHACOIDES) HORNI
Whitney n. sp.
Plate 89, figures 4, 5

Cast small, compressed, subcircular, equivalve, almost equilateral. Beaks small, not

prominent, central, very slightly turned toward the anterior, very close together. Hinge unknown. The anterior and posterior cardinal margins nearly equal in length and sloping. Anterior cardinal margin slightly concave. Posterior cardinal margin straight. Anterior, ventral and posterior margins thin and arcuate; together forming about two-thirds of a circle. The curvature is quite uniform up to the cardinal margins where it flattens out. The posterior is marked by a very faint umbonal ridge which extends from the beaks to the posterior border leaving a narrow, triangular postumbonal slope. Pallial line long, arcuate, entire. Sides of shell show a few concentric, fairly coarse lines. Greatest thickness about the center of the shell. Greatest height at the beaks.

Dimensions.—Height 24 mm., length 28 mm., width 10 mm.

Occurrence.—Northwest of Bandera, Texas on the Hansen ranch; on Little Blanco River on Smithson's Valley-Twin Sister Mountain road; Cranes Mill-Fischer Store road, three miles from Fischer's Store, Texas, 290 feet above Guadalupe River; on the Devil's Backbone ridge near the top of the Glen Rose in Hays County, Texas.

Type locality.—Devil's Backbone ridge, Hays County, Texas.

Genus CORBIS Cuvier

CORBIS HAMILTONAE Whitney, n. sp.
Plate 89, figures 8, 9

Casts large, exceedingly ventricose, height, length and width nearly equal, equivalve, only slightly inequilateral. Beaks nearly central, directed anteriorly, large, rounded, incurved. Hinge arched, warped at the anterior end, showing impressions of two teeth in each valve. Posterior cardinal margin long, steeply sloping, convex, curving evenly to the tips of the beaks. Anterior cardinal margin deeply concave; short, steep, almost vertical. Anterior and posterior margins narrowly rounded, similar in shape and size. Ventral margin broadly rounded, keel-like, crenulate. The pallial line is arcuate, paralleling the ventral margin. Beneath the margin the border of the shell is quite thin, but above it the shell expands suddenly to a great thickness. The greatest height is at the beaks. The greatest thickness is at the center of the shell. No surface markings can be seen on the cast at hand.

Dimensions.—Height 47 mm., length 52 mm., width 43 mm.

Type locality.—Twelve miles south of Boerne, Texas on the Boerne-Bandera road, lower Glen Rose.

CORBIS BANDERAENSIS Whitney, n. sp.
Plate 89, figures 10, 11

Cast subovate, moderately large, very ventricose, equivalve, inequilateral. Beaks blunt, rounded, far apart, quite high, prominent, anterior but twisted very slightly toward the posterior. Hinge with deep and wide impressions of teeth, one showing small grooves along the hinge. Posterior cardinal margin long, quite straight, curved at the outer end. Anterior cardinal margin shorter, arched, steeply sloping and carinate. Anterior margin very short and rounded. Anterior end greatly thickened. Ventral margin profoundly rounded, somewhat carinate, and denticulate. Posterior margin broadly rounded, closed. Posterior end only slightly thinner than the anterior end. The whole shell is greatly inflated. The thickest portion is somewhat below the beaks. The highest portion is at the beaks. Umbonal ridge slightly prominent. Postumbonal slope wide, concave. The pallial line is entire. Anterior muscle scar large, oval, raised on the posterior side. The posterior muscle scar is situated high on the post-umbonal slope, suboval, produced for a short distance up the posterior cardinal margin, marked by curved longitudinal lines and raised on the anterior side. No surface markings are present on the cast.

Corbis banderaensis differs from *C. hamiltonae* in having its beaks very terminal and by being slightly less ventricose.

Dimensions.—Height 50 mm., length 60 mm., width 45 mm.

Type locality.—At the *Salenia texana* horizon on the Hansen ranch 9 miles northwest of Bandera, Texas; upper portion of basal Glen Rose.

REFERENCES

ADKINS, W. S., 1928, Handbook of Cretaceous fossils: Univ. Texas Bull. 2838, 385 pp., 37 pls.

CONRAD, T. A., 1857, Report of the U.S. and Mexico Boundary Survey: vol. 1.

CRAGIN, F. W., 1893, A contribution to the invertebrate paleontology of the Texas Cretaceous: Texas Geol. Survey, 4th Ann. Rep., pt. 2, pp. 139–246.

D'ORBIGNY, ALCIDE, 1843–47, Description des mollusques et rayonées fossiles terraines Crétacés: Paleontologie francais, vols. 2, 3, 4, 6.

ROEMER, F., 1852, Die Kreidebildungen von Texas und ihre organischen Einschlusse, 100 pp., Bonn.

——, 1849, Texas. 464 pp., Bonn.

WHITNEY, F. L., 1928, Bibliography and index of North American Mesozoic invertebrates: Bull. Am. Paleontology, vol. 12, no. 48, 448 pp.

MANUSCRIPT RECEIVED AUGUST 27, 1951

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 708–727, PLS. 90–103, SEPTEMBER 1952

MIDDLE EOCENE FORAMINIFERA FROM PEÑON SEEP, MATANZAS PROVINCE, CUBA

W. STORRS COLE AND DONALD W. GRAVELL*
Cornell University, Ithaca, N. Y. and Gulf Oil Corporation, Havana, Cuba

ABSTRACT—Nineteen species of Foraminifera, including six new species and a new genus, *Penoperculoides*, are described from a six inch layer located at Rancho Peñon, Matanzas Province, Cuba. This fauna which is dominated by discocyclinids is considered to be the approximate equivalent in age of the *Lepidocyclina antillea-Pseudophragmina perpusilla* zone of the Gulf Coast of the United States.

INTRODUCTION

THE occurrence of abundant larger Foraminifera at the asphalt seep and quarry on Rancho Peñon, located 7 kilometers south of Martí (Hato Nuevo) and 850 meters northwest of the little settlement of Peñon, Matanzas Province, Cuba has been known for some years. The late Mrs. Dorothy K. Palmer (1934, p. 259) reported the occurrence at this locality of *Gunteria floridana* Cushman and Ponton in association with abundant other Foraminifera, including *Dictyoconus* and *Discocyclina*. Cushman and Bermudez (1937, pp. 7–9, and 1937a, pp. 107, 108) described certain smaller Foraminifera from this locality, and Cole and Bermudez (1944, pp. 333, 340) discussed specimens of *Fabiania cubensis* (Cushman and Bermudez) which were collected at Peñon Seep.

* Donald W. Gravell died unexpectedly of a heart attack October 14, 1951 as the final manuscript was being typed. Therefore, he could not give his approval to this manuscript, but the senior author believes that he has expressed the ideas held by Mr. Gravell as all points in dispute had been reconciled by an extensive correspondence during the preparation of this article.

The locality at Peñon Seep is placed in the Loma Candela formation (Bermudez, 1950) and is correlated by Bermudez with the Guayabal formation of Mexico and the combined Tallahassee and Lake City limestones of Florida.

In 1940 D. W. Gravell (then employed by the Atlantic Refining Company) became interested in the fauna of Peñon Seep after he examined collections from this locality (A. R. C. No. 5442) made by H. L. Geis. As this material was impregnated by heavy asphalt which interfered somewhat with the examination and study of the specimens, D. W. Gravell and J. B. Klecker in 1941 revisited and recollected at the locality. This selected material yielded a well-preserved fauna which is the basis of this study.

The collection originally made by Gravell and Klecker was supplemented by additional material obtained by Gravell and Emelio Aleman in 1951. Both of these collections came from the lowest 6 inches of strata exposed in an abandoned pit, 8 feet deep, made to obtain road material.

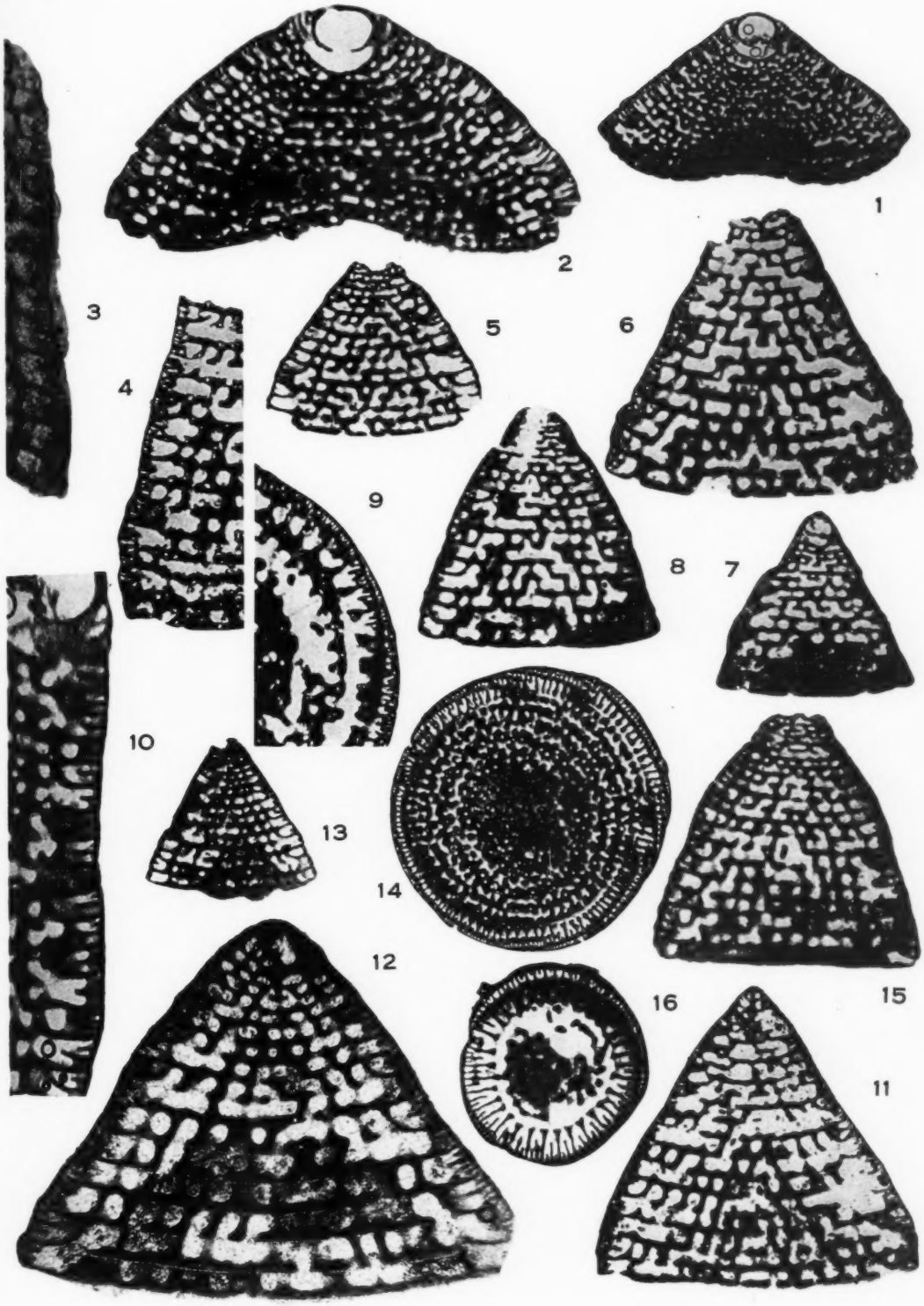
During 1943 Gravell and Enrique Comacho made a number of thin sections of specimens from this fauna, drew up preliminary

EXPLANATION OF PLATE 90

All the specimens used as illustrations are from the Peñon Seep locality except as otherwise designated in the explanation of plates. The entire cost of the printed plates has been contributed equally by the Gulf Oil Corporation and the William F. E. Gurley Fund for Paleontological Research at Cornell University.

FIGS. *1–4, 6, 7, 9–12, 14, 16—Dictyoconus americanus* (Cushman). *1–4, 6, 7, 10–12*, axial sections; *1*, ×12.5; *2, 4, 6, 7, 9, 11*, ×20; *3, 10, 12*, ×40; *9, 14, 16*, transverse sections, ×20; *3, 12*, specimens from the Senn collection, collected from the promontory separating Anse de Lezards and Anse des Cayes on the north coast of St. Bartholomew, French West Indies (p. 711)

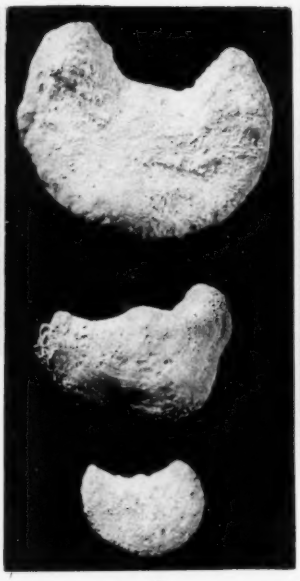
5, 8, 13, 15—Dictyoconus cookei (Moberg). Axial sections, ×20. (p. 711)



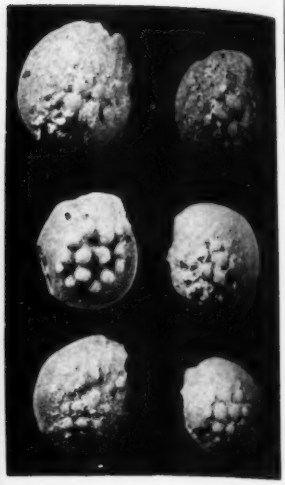
Cole and Gravell, Cuban Eocene Foraminifera

1

3

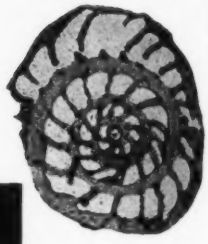


2



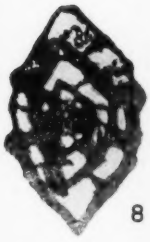
6

4

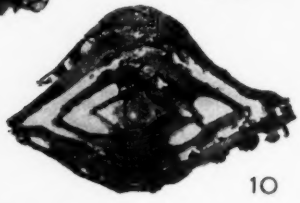


7

5

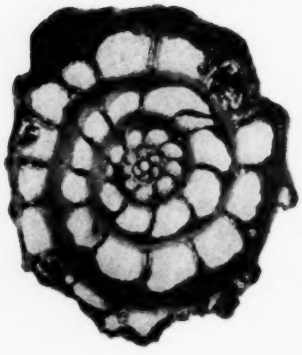


8

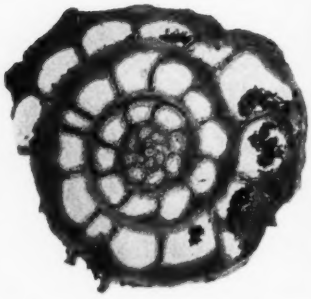


12

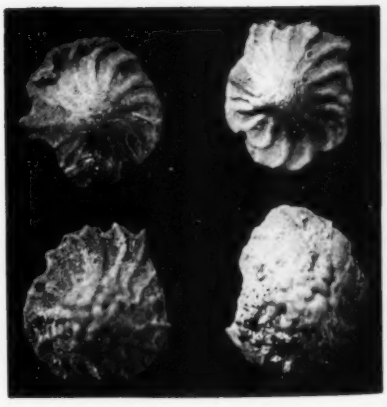
10



11



9



Cole and Gravell, Cuban Eocene Foraminifera

descriptions of the species present and identified a number of species. In 1944 Gravell was transferred to Venezuela, and at that time he forwarded all the material to Dr. T. Wayland Vaughan at the U. S. National Museum. Unfortunately, Vaughan was unable to work on the Peñon material, and eventually he requested Cole to undertake his portion of the work.

Our deepest appreciation is expressed to Mr. R. C. Harris of the Atlantic Refining Company for the permission to publish on this material.

The specimens used in this study are deposited temporarily in the Cole collection at Cornell University but eventually will become the permanent property of the U. S. National Museum.

GEOLOGIC RELATIONSHIPS

Peñon Seep is located in an area of low topographic relief. As the area is deeply covered with residual soil, natural exposures are infrequent and poor.

During 1943 a number of core holes were drilled in the vicinity of Peñon Seep by the Bureau of Economic Warfare under the supervision of the late Dr. R. E. Dickerson. Gravell had the opportunity of examining certain of the cores from these test holes.

These samples demonstrated that the middle Eocene of this area is a lithologic and faunal unit virtually identical with the material on which this article is based. The thickness of this unit varies from a few feet to about 40 feet. The strata appear to be rather massive, and the dip although not readily measurable appears to be low and to the north.

CORRELATION

Although this article is based primarily upon those Foraminifera which must be studied by thin section, certain of the outstanding smaller Foraminifera were identified. These will be included in the discussion of the probable correlation. The previously named species recognized at Peñon Seep, their type localities and occurrences elsewhere follow:

Previously named species	Type locality	Other occurrences
Amphistegina lopeztrigoi Palmer	Cuba	Florida, Mexico
Asterocyclina habanensis Cole and Bermudez	Cuba	
monticellensis Cole and Ponton	Florida	
Dictyoconus americanus (Cushman)	St. Bartholomew	Cuba, Florida
cookei (Moberg)	Florida	Cuba
Discocyclina (*Discocyclina*) *marginata* (Cushman)	St. Bartholomew	Cuba, Barbados
Discorinopsis gunteri Cole	Florida	
Eoconuloides wellsi Cole and Bermudez	Cuba	
Fabiania floridana Cushman and Bermudez	Cuba	Florida, St. Bartholomew
Gunteria floridana Cushman and Ponton	Florida	Cuba
Helicostegina gyralis Barker and Grimsdale	Mexico	Cuba, Florida
Pseudophragmina (*Proporocyclina*)		
cushmani (Vaughan)	Mexico	Cuba
psila (Woodring)	California	
Spirolina coryensis Cole	Florida	
Textularia coryensis Cole	Florida	
Valvulina martii Cushman and Bermudez	Cuba	Florida

EXPLANATION OF PLATE 91

FIGS. *1–4*—*Gunteria floridana* Cushman & Ponton. *1*, external view, ×10, to illustrate the marginal pores and the chamberlets; *2*, external views, ×5, of 3 specimens to show size and general form; *3*, transverse section, ×20; *4*, median section, ×20. (p. 712)

5—*Discorinopsis gunteri* Cole. External views of 4 specimens, those on the right show the ventral surface, ×20. (p. 714)

6–8—*Amphistegina lopeztrigoi* D. K. Palmer, *6*, external views, ×10, of 6 specimens; *7*, median section, ×20; *8*, transverse section, ×20. (p. 714)

9–12—*Penoperculoides cubensis* Cole & Gravell, n. sp. *9*, external views, ×10, of 4 specimens; upper left specimen holotype, Cole collection No. 410; *10*, transverse section, ×20; *11*, *12*, median sections, ×20. (p. 714)

The most distinctive species in this list is *Gunteria floridana* which was described from the Suwannee Petroleum Corporation's Sholtz well No. 1 located in Levy County, Florida. Cole (1942) reports that the base of the Ocala limestone (upper Eocene) occurs at about 140 feet in this well. In the middle Eocene he recognizes the following zones: 1. *Dictyoconus cookei* zone at 145 feet; 2. *Fabularia vaughani* zone at 310 feet; 3. *Dictyoconus americanus* zone at 840 feet; 4. *Gunteria floridana* zone at 1100 feet; and 5. *Amphistegina lopeztrigoi* zone at 1340 feet. Of the species used to demark these five zones in Florida, four occur together at Peñon Seep.

Applin and Applin (1944) attempt to divide the subsurface Eocene of Florida into formations according to the following divisions:

Age	Formation	Key fossils*
Late middle Eocene	Avon Park limestone	*Dictyoconus cookei* (Moberg) *Discorinopsis gunteri* Cole *Spirolina coryensis* Cole *Textularia coryensis* Cole *Valvulina martii* Cushman and Bermudez
	Tallahassee limestone	non-fossiliferous
Early middle Eocene	Lake City limestone	*Amphistegina lopeztrigoi* D. K. Palmer *Asterocyclina monticellensis* Cole and Ponton *Dictyoconus americanus* (Cushman) *Fabiania cubensis* (Cushman and Bermudez) *Gunteria floridana* Cushman and Ponton
Lower Eocene	Oldsmar limestone	*Helicostegina gyralis* Barker and Grimsdale

* Selected from lists given by Applin and Jordan (1945) to match the species present at Peñon Seep.

and *Fabiania cubensis* (Cushman and Bermudez).

In Florida Cole (1944) defined in the St. Mary's Oil Corporation, Hilliard Turpentine Company well No. 1 the subsurface continuation of the Lisbon formation to include the *Dictyoconus cookei*, the *D. americanus*, the *L.* (*Polylepidina*) *antillea* and the *Amphistegina lopeztrigoi* zones. This interval in the well extends from 860 to 1350 feet.

In this same interval Applin and Applin (1944, p. 1745) recognize the Avon Park limestone, the non-fossiliferous equivalent of the Tallahassee limestone and the Lake City limestone. It would appear that the 6 inch bed at Peñon Seep contains many of the key fossils by which three or four formations in Florida are recognized.

The fauna at Peñon Seep is approximately the equivalent of the *Pseudophragmina per-*

Of the 16 previously named species considered at Peñon Seep, 11 occur in Florida, and according to Applin and Jordan range from lower Eocene to late middle Eocene.

Pseudophragmina (*Proporocyclina*) *cushmani* (Vaughan) occurs in the Guayabal beds of Mexico (Muir, 1936, p. 114) at an horizon virtually the same as that of *P.* (*P.*) *perpusilla*. Gravell and Hanna (1938) place the *P.* (*P.*) *perpusilla* zone of Louisiana and Texas in the Cook Mountain formation of the Claiborne. In this area *P.* (*P.*) *perpusilla* occurs with *Lepidocyclina* (*Polylepidina*) *antillea* Cushman.

At St. Bartholomew *D.* (*D.*) *marginata* occurs with *L.* (*Polylepidina*) *antillea* Cushman, *Dictyoconus americanus* (Cushman)

pusilla-Lepidocyclina antillea zone of Texas and Louisiana as defined by Gravell and Hanna (1938), that is, it occurs near the base of the Cook Mountain formation of the Claiborne group.

However, it should be noted that Gravell considers this fauna to be slightly older than the *P. perpusilla-L. antillea* zone as he believes it developed before the appearance of *Lepidocyclina* (*Polylepidina*) and *Operculinoides* in this area. Cole, on the other hand, believes this fauna to be contemporaneous with the *P. perpusilla-L. antillea* fauna, and that these species do not occur in this particular area because of ecological conditions.

Although the conditions would seem

favorable at Peñon Seep for the existence of *Lepidocyclina* and *Operculinoides*, it should be noted that *L.* (*Polylepidina*) *antillea* has a very irregular geographic distribution in Florida. It occurs much more frequently in sediments which tend to be sandy than it does in limey sediments. Some such control may have operated in Cuba.

COMPARISON WITH OTHER CUBAN FAUNAS

There is some similarity in the fauna of Peñon Seep with one described by Cole and Bermudez (1947) from the cut at Finca "La Coronela" on the road from Habana to Rancho Boyeros, Habana Province (Bermudez station 1266). The following species are common to both localities:

Amphistegina lopeztrigoi D. K. Palmer
Asterocyclina habanensis Cole and Bermudez
Dictyoconus americanus (Cushman)
cookei (Moberg)
Discocyclina (*Discocyclina*) *marginata* (Cushman)
Eoconuloides wellsi Cole and Bermudez
Pseudophragmina (*Proporocyclina*) *cushmani* (Vaughan)

Cole and Bermudez (1947, p. 193) wrote concerning the fauna of station B-1266: "The presence of *Dictyoconus* of the *americanus* type and of *P.* (*Proporocyclina*) *cushmani* causes us to place the fauna of station 1266 in the middle Eocene . . ." Later Bermudez (1950, p. 230) assigns this fauna (station B-1266) to the Lucero member of the Capdevila formation. The Capdevila formation is placed by Bermudez at the base of the lower Eocene.

The present writers agree with the opinion expressed by Cole and Bermudez in 1947 that the fauna from station B-1266 is middle Eocene. It should be pointed out, however, that the fauna from station B-1266 contains much reworked material from the Upper Cretaceous, and probably from the Paleocene and lower Eocene as well.

At the present time we consider the locality at Finca "La Coronela" (station B-1266) represents middle Eocene, stratigraphically lower than the Peñon Seep fauna. The type locality of the Loma Candela formation (Bermudez station 261) is stratigraphically slightly higher than the Peñon Seep locality.

DESCRIPTION OF SPECIES

Family VALVULINIDAE

Genus DICTYOCONUS Blanckenhorn, 1900

DICTYOCONUS AMERICANUS (Cushman)

Plate 90, figures 1–4, 6, 7, 9–12, 14, 16

Conulites americana CUSHMAN, 1919, Carnegie Inst. Washington, Publ. 291, p. 43, text fig. 3.
Dictyoconus americanus (Cushman). COLE, 1942, Florida Geol. Survey Bull. 20, pp. 21–24, pl. 3, figs. 12, 13; pl. 6, figs. 1–9; pl. 7, figs. 1–5; pl. 16, figs. 14, 15 (references and synonymy); 1944, idem, Bull. 26, pp. 36, 37, pl. 4, figs. 1–6; pl. 8, figs. 12, 13; pl. 18, fig. 11; 1945, idem, Bull. 28, p. 97, pl. 12, fig. 3.

Cole (1942, pp. 21–24) studied specimens of *Dictyoconus* from deep wells in Florida and combined several species under the name *D. americanus*. These species were: *D. codon* Woodring, *D. puilboreauensis* Woodring and *D. gunteri* Moberg. At that time Cole published a transverse section of *D. americanus* from St. Bartholomew. This island is the type locality of *Conulites americana*. Since that time a large collection from St. Bartholomew made by the late Dr. Alfred Senn was sent to Cole for study by Dr. T. Wayland Vaughan. It is, therefore, possible to illustrate at this time axial sections of specimens from St. Bartholomew (pl. 90, figs. 3, 12).

The axial sections of the St. Bartholomew specimens have three or four short lamellae between the peripheral platforms. Although a single specimen normally has marginal chamberlets with both three or four short lamellae, there is generally a predominance of one number or the other in an individual specimen. Vaughan (1928, p. 281) and Cole (1944, p. 37) have noted this condition previously.

DICTYOCONUS COOKEI (Moberg)

Plate 90, figures 5, 8, 13, 15

Coskinolina cookei MOBERG, 1928, Florida Geol. Survey 19th Ann. Rept., pp. 166–168, pl. 3, figs. 1–5, 7, 8 (not fig. 6).
Dictyoconus cookei (Moberg). COLE, 1941, Florida Geol. Survey Bull. 19, pp. 26, 27, pl. 3, fig. 11–13; pl. 5, figs. 6–10, 12, 13; pl. 6, figs. 1–8; pl. 18, fig. 12; 1942, idem. Bull. 20, pp. 24, 25, pl. 3, fig. 10; pl. 4, fig. 8; 1945, idem, Bull. 28, pp. 26, 97, pl. 2, figs. 1, 2; pl. 12, figs. 2, 6, 8.

The axial sections of this species show the marginal chamberlets with a single, horizontal plate. The Cuban specimens are en-

tirely comparable to those found in deep wells in Florida.

Family CYMBALOPORIDAE
Genus FABIANIA A. Silvestri, 1926
FABIANIA CUBENSIS
(Cushman & Bermudez)

Pseudorbitolina cubensis CUSHMAN & BERMUDEZ, 1936, Contrib. Cushman Lab. Foram. Res., vol. 12, p. 59, pl. 10, figs. 27–30.
Eodictyoconus cubensis COLE & BERMUDEZ, 1944, Bull. Amer. Paleont., vol. 28, no. 113, pp. 336–340, pl. 1, fig. 1; pl. 2, figs. 1–12; pl. 3, fig. 1–5 (references).

Entirely typical specimens occur, but not in the abundance of most of the other species.

Genus GUNTERIA Cushman & Ponton, 1933
GUNTERIA FLORIDANA Cushman & Ponton
Plate 91, figures 1–4

Gunteria floridana CUSHMAN & PONTON, 1933, Contrib. Cushman Lab. Foram. Res., vol. 9, pp. 25–30, pl. 3, figs. 1–3; —— D. K. PALMER, 1934, Soc. Cubana Hist. Nat. Mem., vol. 8, pp. 257–259, pl. 15, figs. 5, 7, 9; pl, 16, figs. 1, 2, 4, 5, 8; —— L. M. DAVIES, 1939, Roy. Soc. Edinburgh Trans., vol. 59, p. 780, pl. 1, figs. 2, 5, 8, 10, 11; —— COLE, 1942, Florida Geol. Survey Bull. 20, pp. 28, 29, pl. 16, figs. 1–4.

This genus was assigned originally to the family *Valvulinidae* by Cushman and Ponton. Later, Davies (1939, p. 780) proved that the wall is perforate, hyaline and the internal organization is different from that of *Dictyoconus*. Cole (1942, p. 28) suggested placing this genus in the family Buliminidae. The thin sections used in this study demonstrate, however, that the wall structure of *Gunteria* is very similar to that shown by *Cymbalopora irregularis* Keijer (= *C. cushmani* Cole and Bermudez) and *Fabiania cubensis* (Cushman and Bermudez). The genus *Gunteria* is, therefore, transferred to the family Cymbaloporidae.

Distribution.—This species was described from the Suwannee Petroleum Corporation's Sholtz well No. 1, Levy County, Florida where it occurs at depths of 1055 to 1100 feet in middle Eocene strata. It has been reported from other deep wells in Florida. In Cuba this species occurs at

---

EXPLANATION OF PLATE 92

FIGS. *1–10—Eoconuloides wellsi* Cole & Bermudez. *1–6*, axial sections, ×20, except *5*, ×40; *7–10*, transverse sections, ×20. (p. 713)
11–21—Helicostegina gyralis Barker & Grimsdale. *11–14*, axial sections, ×20; *15–19*, transverse sections, ×20; *20*, external views, ×5, of 2 microspheric specimens; *21*, external views, ×10, of 3 megalospheric specimens. (p. 713)

EXPLANATION OF PLATE 93

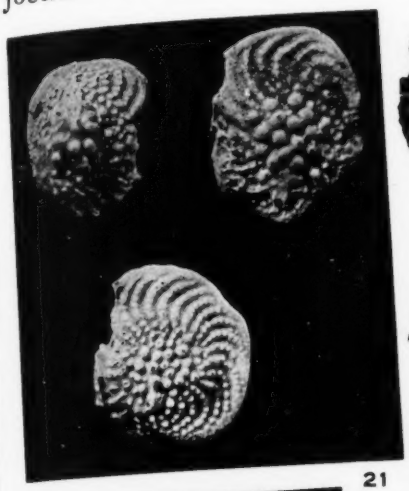
FIGS. *1–9—Discocyclina* (*Discocyclina*) *marginata* (Cushman). Vertical sections to illustrate the difference in external shape and internal features between individuals, *1*, *2*, *4–9*, ×20; *3*, ×12.5; *2*, a specimen from the Senn collection, collected on the northeast ridge of the small rocky island of Pain de Sucre, west of Gustavia, St. Bartholomew, French West Indies; *3*, *4*, specimens from Angelita Seep, about 4 kms. S 60° W of Peñon Seep. (p. 714)

EXPLANATION OF PLATE 94

FIGS. *1–8—Discocyclina* (*Discocyclina*) *marginata* (Cushman). *1–3*, vertical sections, *1*, ×12.5; *2*, *3*, ×20; *4*, equatorial section, ×20; *5–8*, portions of equatorial sections to demonstrate the position of the annular stolon, ×210; all the photographs are oriented so that the distal side of the radial chamber wall is at the top; *6*, *8*, portions of the same specimen illustrated as fig. *4*; *1*, *2*, *4*, *6*, *8*, from specimens from the Boston Manganese Mine, Santiago (Oriente) Province, Cuba, presented to W. S. Cole by Dr. Pedro J. Bermudez; *3*, specimen from Angelita Seep, about 4 kms. S 60° W of Peñon Seep. (p. 714)

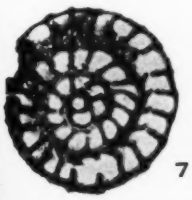
EXPLANATION OF PLATE 95

FIGS. *1–3*, *5—Asterocyclina habanensis* Cole & Bermudez. Equatorial sections, ×20, to illustrate difences in size and number of rays. (p. 716)
4—Asterocyclina monticellensis Cole & Ponton. Equatorial section, ×20. (p. 718)
6—Pseudophragmina (*Proporocyclina*) *compacta* Cole & Gravell, n. sp. Portion of an equatorial section, ×20, to illustrate multiple embryonic chambers. (p. 720)
7, *8—Discocyclina* (*Discocyclina*) *marginata* (Cushman). Equatorial sections, ×20. (p. 714)

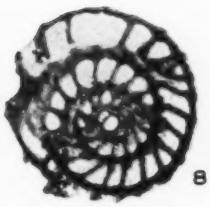


21

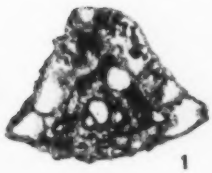
20



7

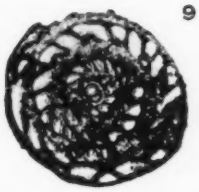


8

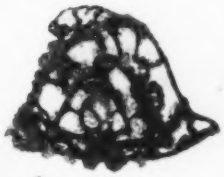


1

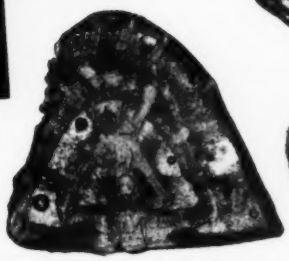
6



9

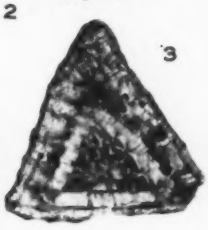


2

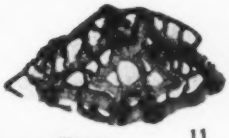


5

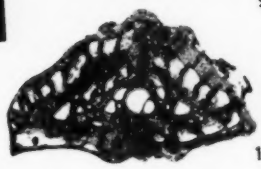
10



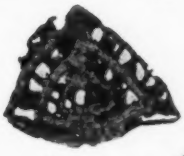
3



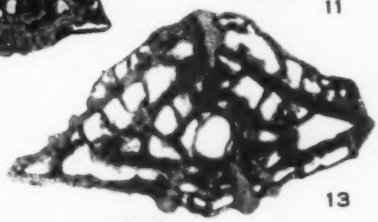
11



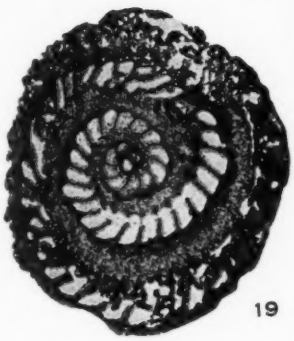
12



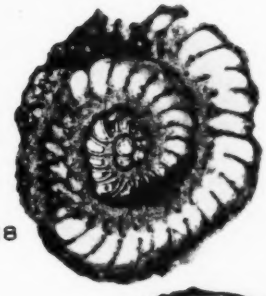
4



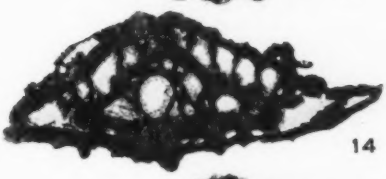
13



19

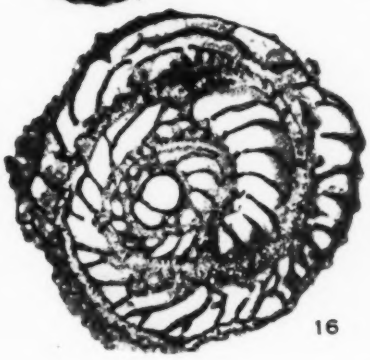


18

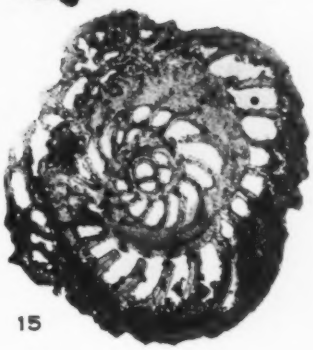


14

17

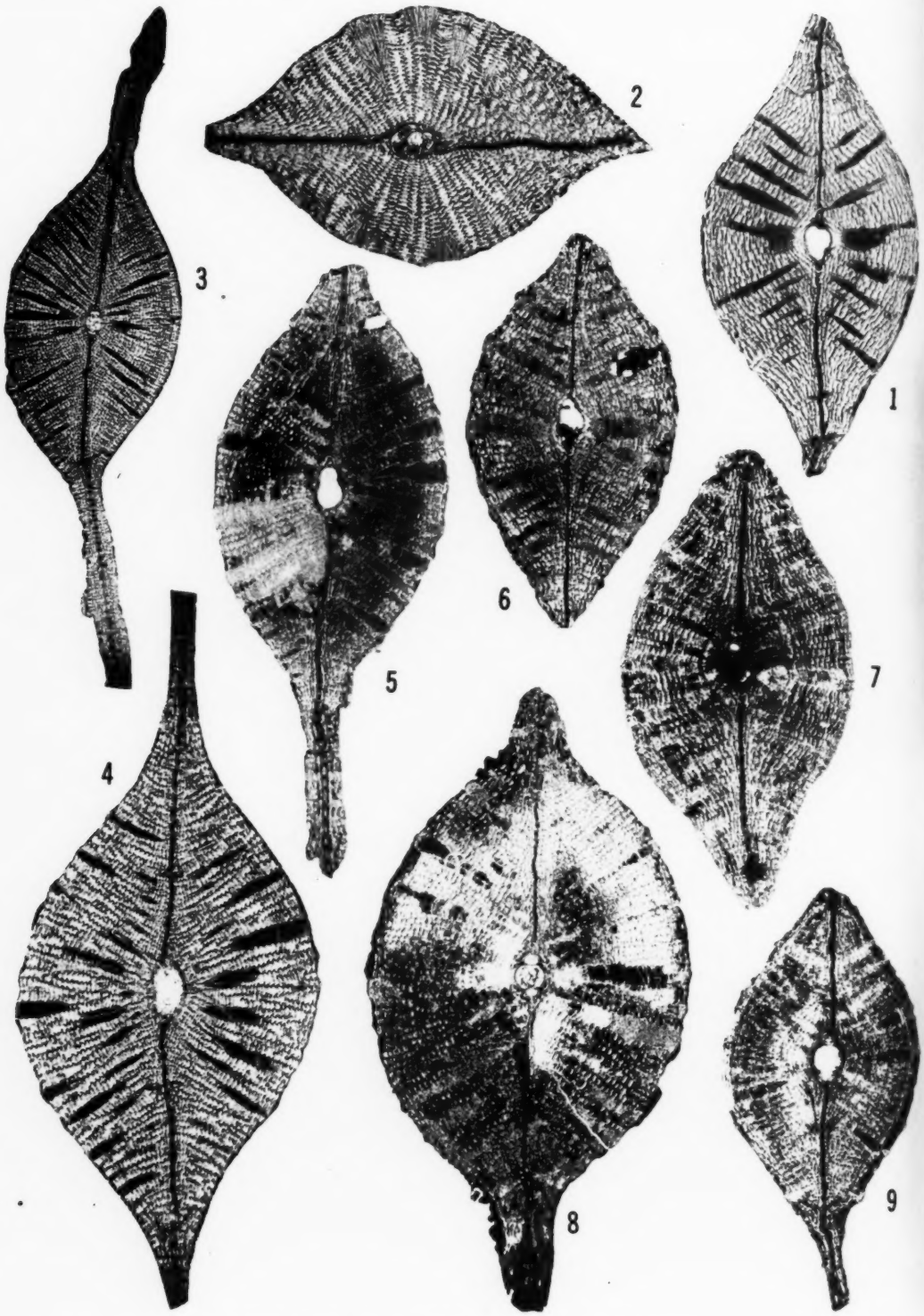


16

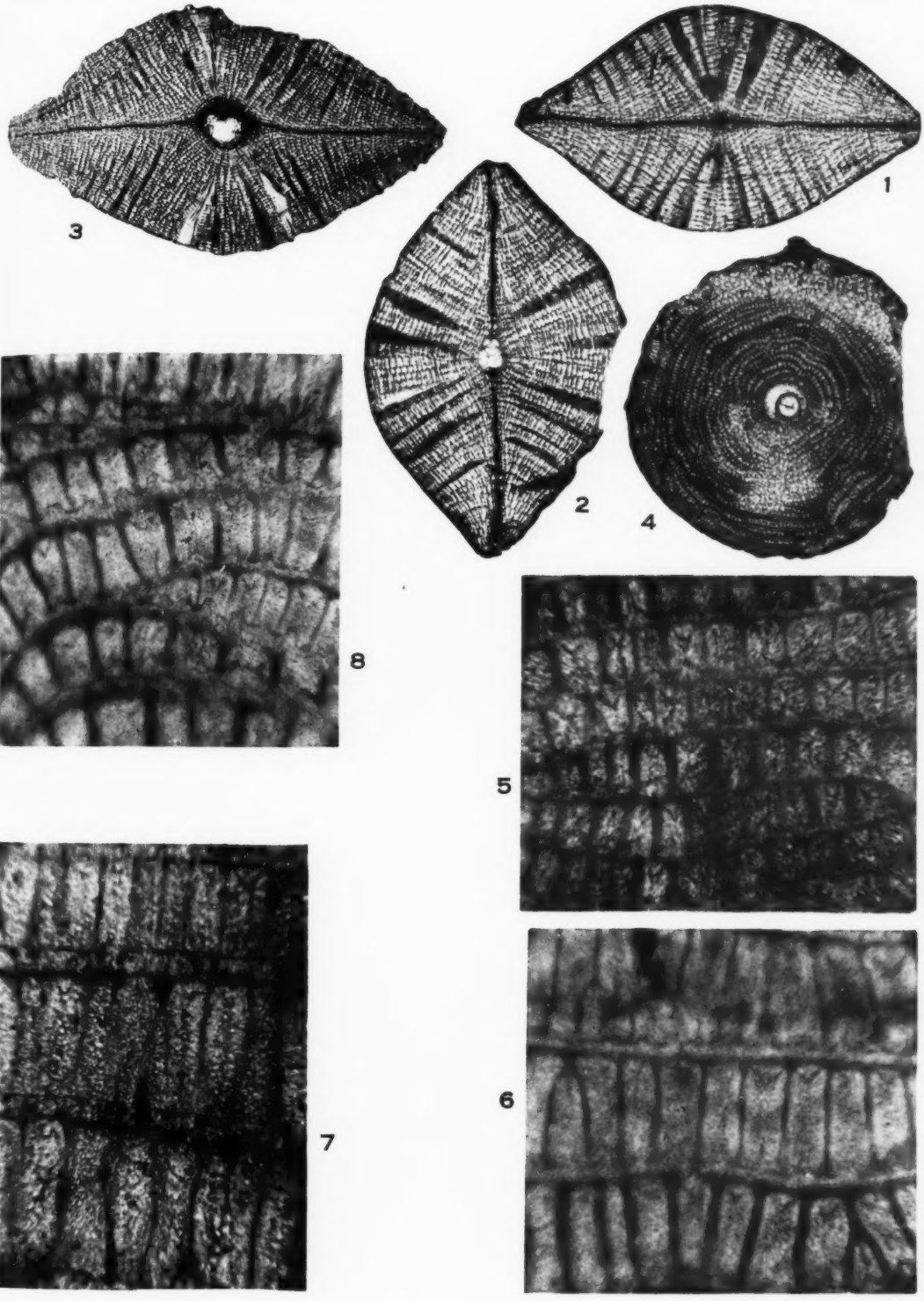


15

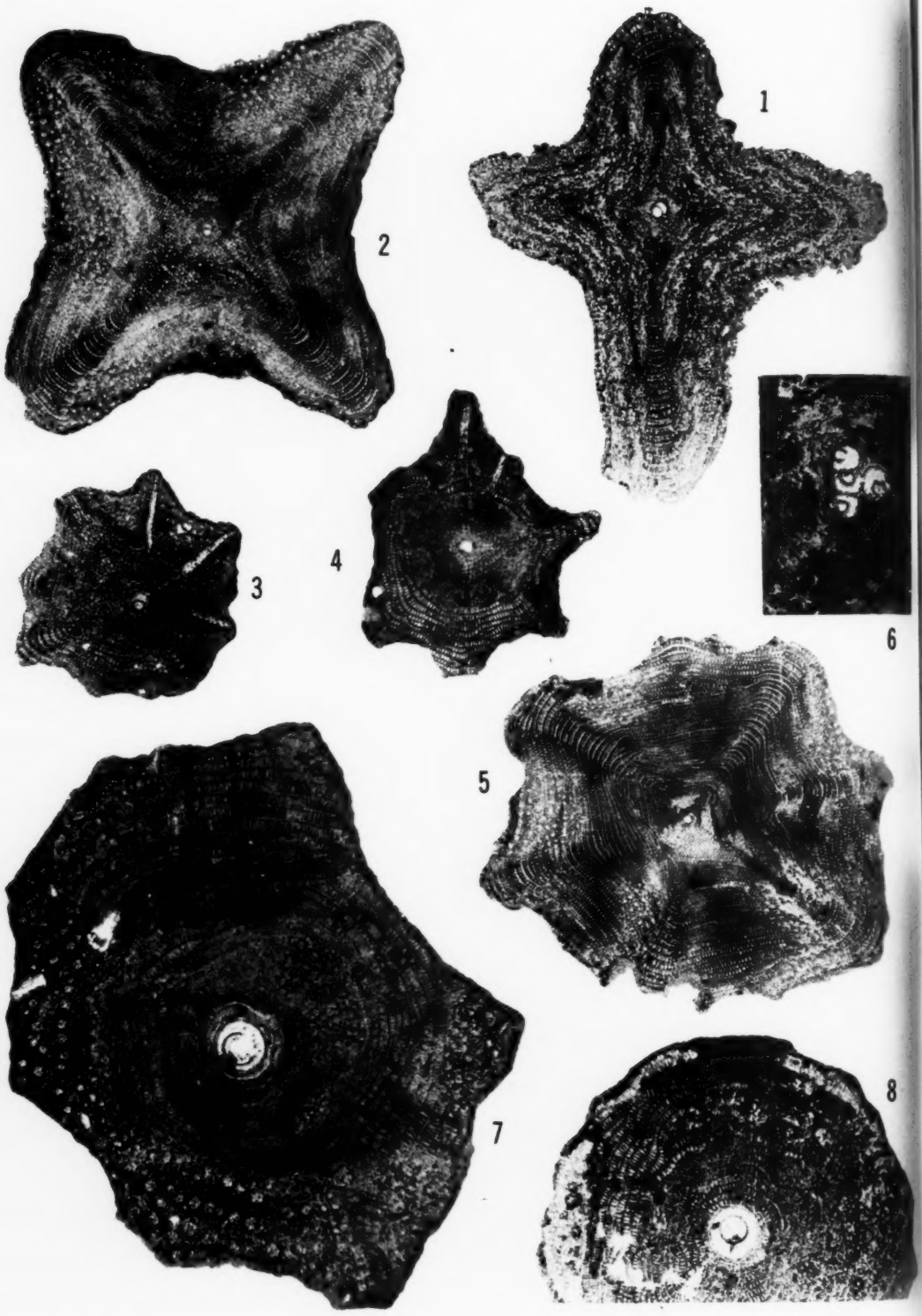
Cole and Gravell, Cuban Eocene Foraminifera



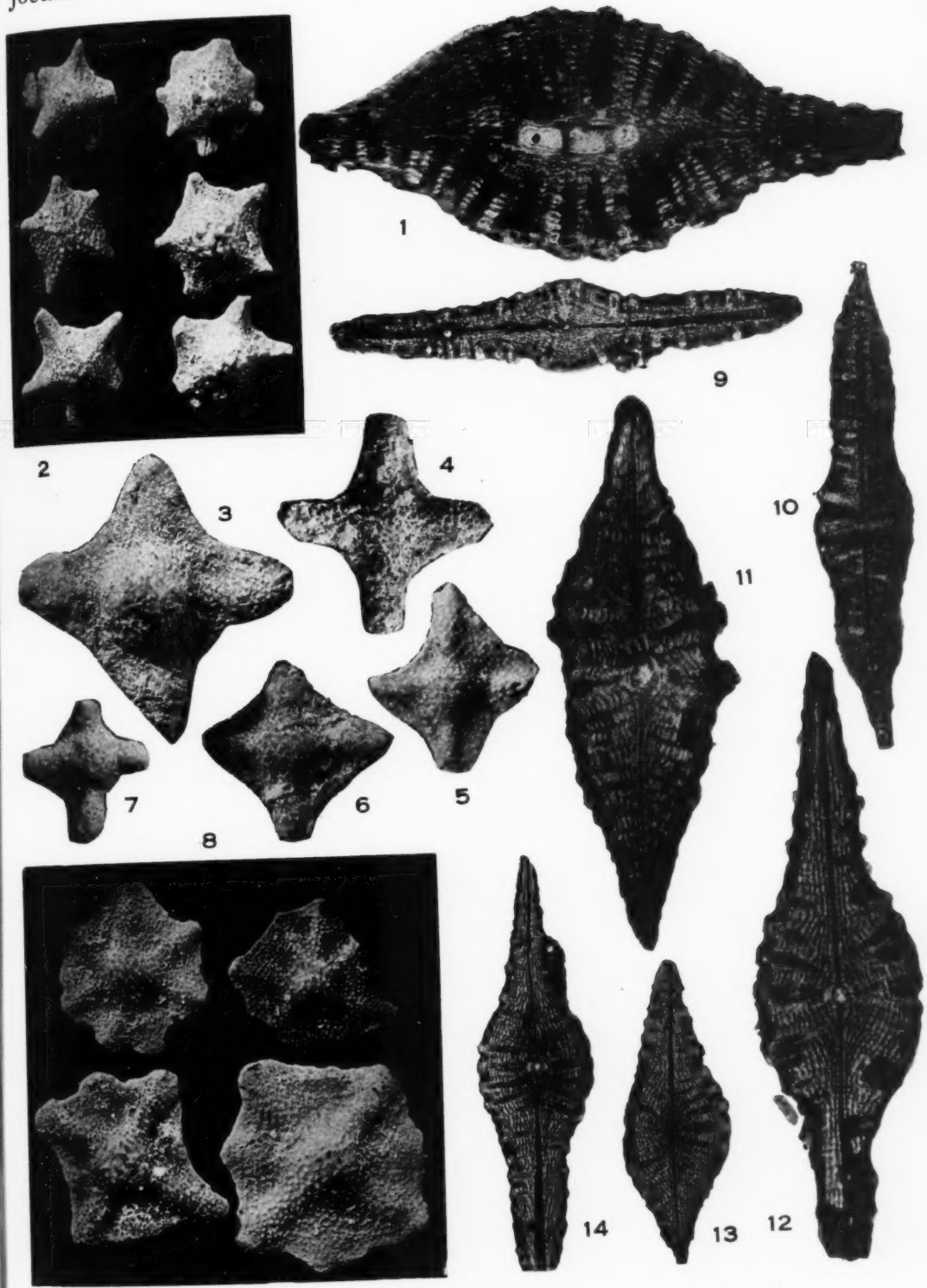
Cole and Gravell, Cuban Eocene Foraminifera



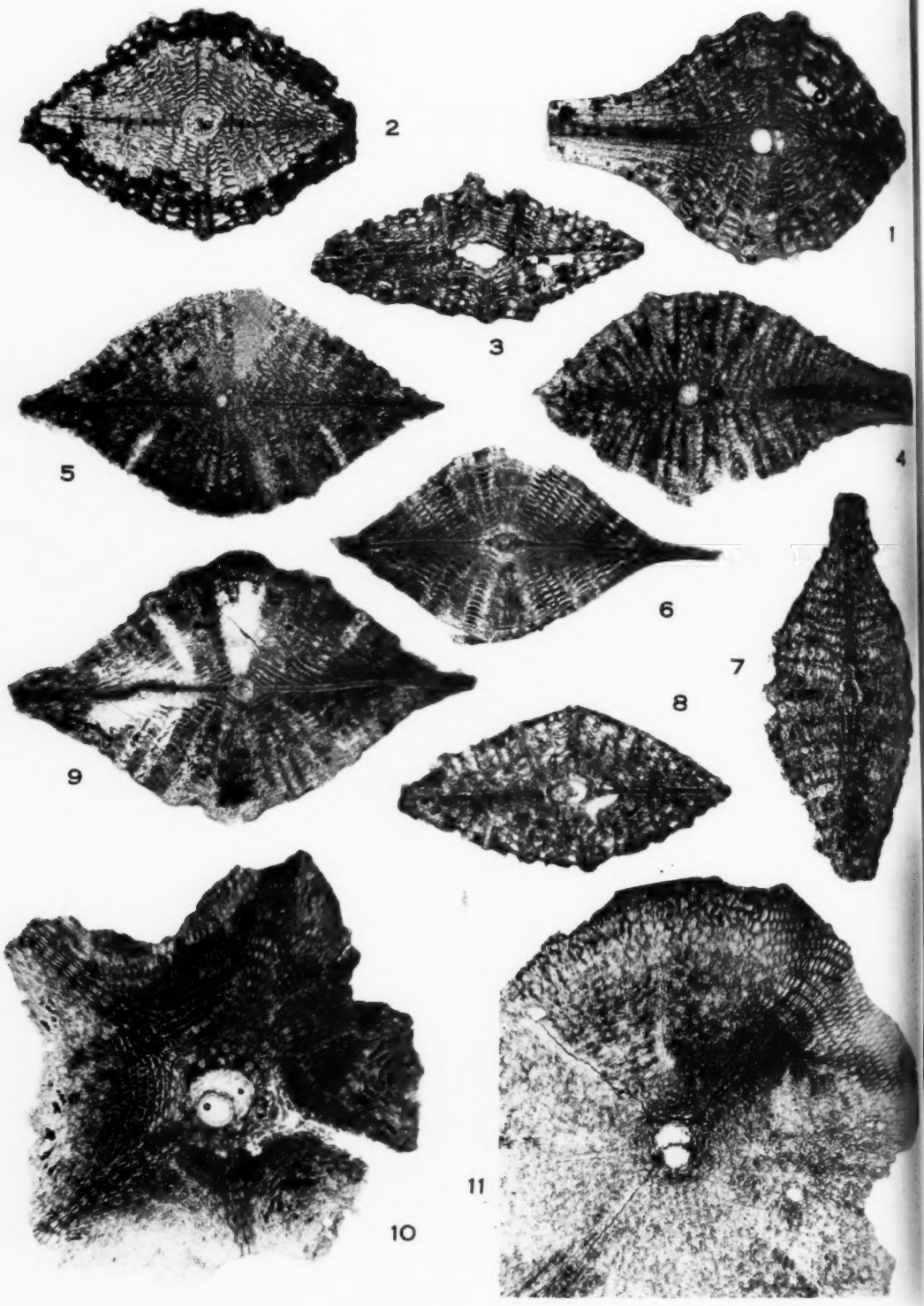
Cole and Gravell, Cuban Eocene Foraminifera



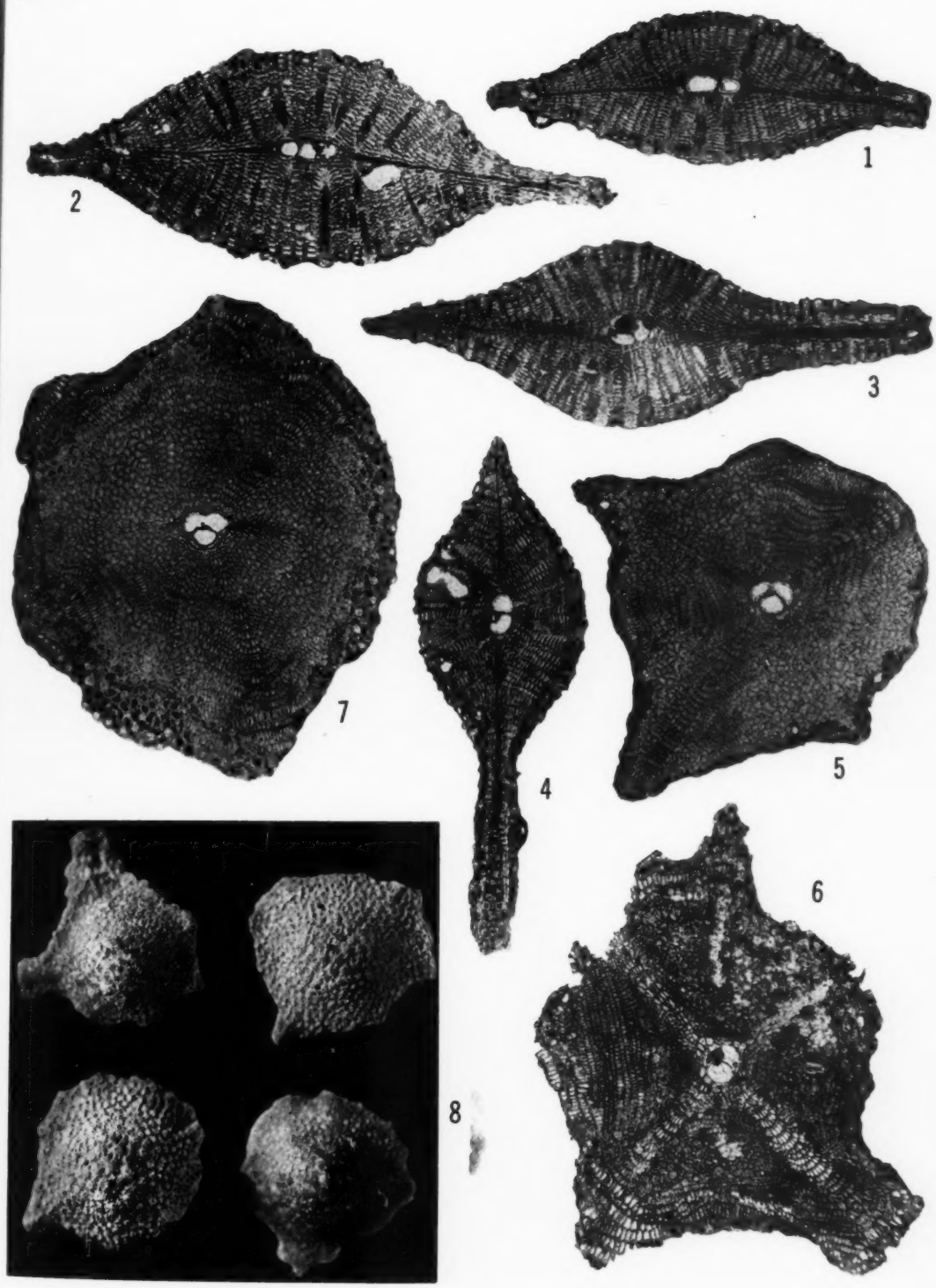
Cole and Gravell, Cuban Eocene Foraminifera



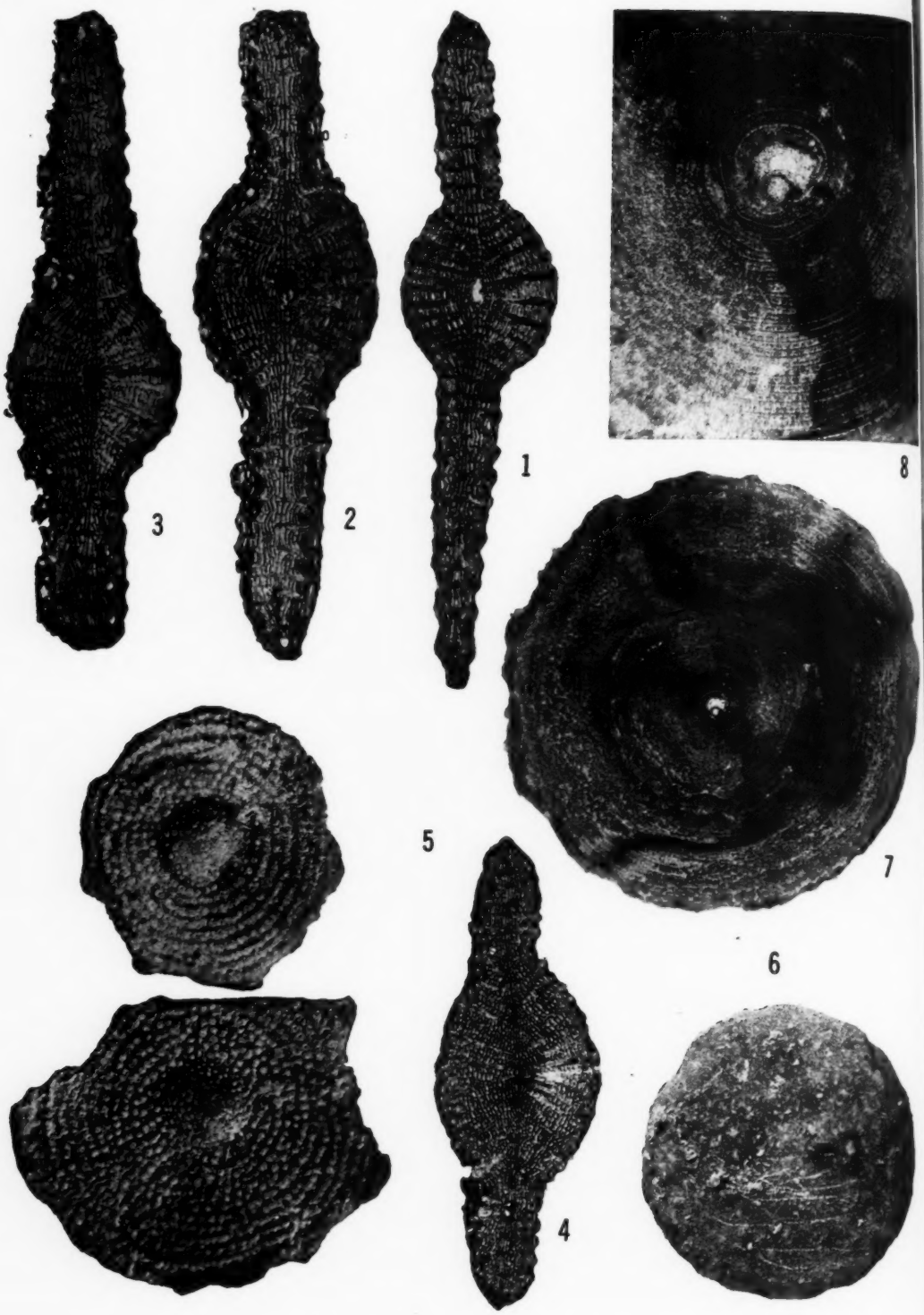
Cole and Gravell, Cuban Eocene Foraminifera



Cole and Gravell, Cuban Eocene Foraminifera



Cole and Gravell, Cuban Eocene Foraminifera



Cole and Gravell, Cuban Eocene Foraminifera

Bermudez station 337A, 4.5 kilometers west of Guanajay on the road to Mariel, Pinar del Rio Province, the locality under discussion and the immediate vicinity. It is a very distinctive species.

Family AMPHISTEGINIDAE
Genus HELICOSTEGINA Barker & Grimsdale, 1936
HELIOCOSTEGINA GYRALIS
Barker & Grimsdale
Plate 92, figures 11–21

Helicostegina gyralis BARKER & GRIMSDALE, 1936, Jour. Paleontology, vol. 4, pp. 236, 237, pl. 30, figs. 3–5; pl. 32, figs. 4, 5; pl. 34, figs. 2–6; pl. 37, figs. 6; —— COLE, 1942, Florida Geol. Survey Bull. 20, p. 34, pl. 15, figs. 4–6; pl. 16, fig. 10.

There is a serious question whether this species can be separated from *H. dimorpha* Barker and Grimsdale (1936, p. 235). These authors (p. 237) state: "*Helicostegina gyralis* is the more primitive of the two species here referred to that genus. It differs from *H. dimorpha* in the possession of a greater number of whorls in the spire, and in the absence of a flange."

At first, in the very abundant material from Peñon Seep two species of *Helicostegina* were recognized. But, on detailed study these appear to form a continuous series. The number of whorls and the degree of development of the flange appear to be individual rather than specific features.

The development of the peripheral subsidiary chamberlets varies from individual to individual. Moreover, the direction in which the thin section passes through the individual governs the number and manner in which the subsidiary chamberlets will appear in the completed thin section.

Genus EOCONULOIDES Cole & Bermudez, 1944
EOCONULOIDES WELLSI
Cole & Bermudez
Plate 92, figures 1–10

Eoconuloides wellsi COLE & BERMUDEZ, 1944, Bull. Amer. Paleont., vol. 28, no. 113, pp. 341, 342, pl. 1, figs. 4–10.

Individuals vary from high conical (pl. 92, fig. 3) to low conical (pl. 92, fig. 6) in cross-sectional form. The flat base of many individuals has a central group of papillae which appear internally as short pillars (pl. 92, fig. 2). However, other individuals which appear to be in all other respects similar to the papillate forms do not possess the external papillae or the internal pillars. Reexamination of the type specimens which are not nearly as well preserved as those from Peñon Seep demonstrates that this variation occurs in these specimens also.

EXPLANATION OF PLATE 96

FIG. *1*—*Asterocyclina penonensis* Cole & Gravell, n. sp. Vertical section, ×40, of a specimen which externally resembled *A. monticellensis*. (p. 718)
2—*Asterocyclina monticellensis* Cole & Ponton. External views, ×10, of 6 specimens. (p. 718)
3–14—*Asterocyclina habanensis* Cole & Bermudez. *2–8*, external views, ×10, to illustrate specimens with 4 rays and lacking interray webbing through 8-rayed specimens with completely developed interray areas; *9–14*, vertical sections, *9*, *10*, *13*, *14*, ×20; *11*, *12*, ×40. (p. 716)

EXPLANATION OF PLATE 97

FIGS. *1–11*—*Asterocyclina monticellensis* Cole & Ponton. *1–9*, vertical sections, ×40, to show differences in internal structure between individuals; *10*, *11*, equatorial sections, ×40. (p. 718)

EXPLANATION OF PLATE 98

FIGS. *1–8*—*Asterocyclina penonensis* Cole & Gravell, n. sp. *1–4*, vertical sections, ×20; *5–7*, equatorial sections, ×20; *8*, external views, ×10, of 4 specimens; upper right specimen, holotype, Cole collection No. 407. (p. 718)

EXPLANATION OF PLATE 99

FIGS. *1–5*—*Pseudophragmina* (*Proporocyclina*) *cushmani* (Vaughan). *1–4*, vertical sections, ×20; *5*, external views of 2 specimens, ×10. (p. 722)
6–8—*Pseudophragmina* (*Proporocyclina*) *compacta* Cole & Gravell, n. sp. *6*, external view, ×10 of holotype, Cole collection No. 409; *7*, equatorial section, ×20; *8*, embryonic and equatorial chambers, ×40, of the same specimen. (p. 720)

Genus AMPHISTEGINA d'Orbigny, 1826
AMPHISTEGINA LOPEZTRIGOI Palmer
Plate 91, figures 6–8

Amphistegina lopeztrigoi PALMER, 1934, Mem. Soc. Cubana Hist. Nat., vol. 8, no. 4, p. 255, pl. 15, figs. 6, 8. —— BARKER & GRIMSDALE, 1936, Jour. Paleontology, vol. 10, p. 233, pl. 30, figs. 1, 2; pl. 32, figs. 1–3; pl. 34, fig. 1; pl. 38, fig. 3; —— COLE, 1942, Florida Geol. Survey Bull. 20, pp. 33, 34, pl. 15, figs. 2, 3; pl. 16, fig. 11; 1944, idem, Bull. 26, p. 55, pl. 1, fig. 17; pl. 8, fig. 16; pl. 9, figs. 10–13.
Amphistegina senni CUSHMAN in Vaughan, 1945, Geol. Soc. America, Mem. 9, p. 49, pl. 19, figs. 1–4.

We have abundant topotype material of this species from Palmer Sta. 687. These specimens range in size from 1.0 mm. to 2.8 mm. Barker and Grimsdale (1936, p. 236) give the diameter of Mexican specimens as 1.0 to 1.5 mm. Cole (1942, p. 33) states the largest Floridian specimens have a diameter of 1.8 mm.

Cushman separates *A. senni* from *A. lopeztrigoi* by its smaller size, fewer chambers and fewer but more prominent bosses in the umbonal region. However, it would be impossible to distinguish between the smaller topotype specimens of *A. lopeztrigoi* and the larger (diameter up to 1.10 mm.) specimens of *A. senni*. It is logical, therefore, to combine these species.

Genus PENOPERCULOIDES
Cole and Gravell, new genus

Genotype.—Penoperculoides cubensis Cole and Gravell, new species.

Test slightly asymmetrical, trochoid in the early stages, adult nearly planispiral, involute; wall calcareous, laminated, and finely tubulated; aperture, an arched slit at the base of the last formed chamber so arranged that it extends more on one side of the median line than the other.

Penoperculoides differs from *Operculinoides* in being slightly asymmetrical and having a much thicker revolving wall. *Penoperculoides* differs from *Crespinella* in having thinner walls and an aperture without a hood. *Penoperculoides* is intermediate in most of its features between *Amphistegina* and *Operculinoides*.

PENOPERCULOIDES CUBENSIS Cole & Gravell, n. sp.
Plate 91, figures 9–12

Test with prominent umbos bordered by a thin flange, slightly asymmetric in cross section. On one side there is a single, large boss in the umbonal region, but on the opposite side there is a group of about 14 raised papillae. The flange on both sides is crossed by raised, distinct sutures which radiate from the umbonal areas. These raised sutures are straight and radial until the periphery is approached at which point they recurve. The sutures on the side of the single boss are not beaded, but on the papillate side the sutures may be beaded near the umbonal area. Diameter, about 2.2 mm.; thickness, about 1.2 mm.

The embryonic chambers are bilocular, the initial chamber is subcircular with an internal diameter of about 55 μ, the second chamber is reniform with diameters of about 40 by 65 μ.

The test is composed of $4\frac{1}{2}$ whorls with 6 chambers in the first whorl, 9 chambers in the second, 10 chambers in the third and 13 chambers in the fourth whorl.

The aperture is an arched slit at the base of the last formed chamber so arranged that it extends more on the unbeaded side of the test than on the other.

Family ROTALIIDAE
Genus DISCORINOPSIS Cole
DISCORINOPSIS GUNTERI Cole
Plate 91, figure 5

Discorinopsis gunteri COLE, 1941, Florida Geol. Survey Bull. 19, pp. 36, 37, pl. 1, figs. 7–9.

Entirely typical specimens occur abundantly at Peñon Seep.

Family DISCOCYCLINIDAE
Genus DISCOCYCLINA Gümbel, 1870
Subgenus DISCOCYCLINA Gümbel, 1870
DISCOCYCLINA (DISCOCYCLINA) MARGINATA (Cushman)
Plate 93, figures 1–9; plate 94, figures 1–8; plate 95, figures 7, 8

Orthophragmina marginata CUSHMAN, 1919, Carnegie Inst. Washington, Publ. 291, p. 56, pl. 1, fig. 2; pl. 2, fig. 4.
Orthophragmina crassa CUSHMAN, 1919, idem, p. 53, pl. 9, figs. 4, 5; pl. 10, figs. 2, 4.
Discocyclina californica SCHENCK, 1929, Trans. San Diego Soc. Nat. Hist., vol. 5, no. 14, pp.

224–227, pl. 27, figs. 3, 4, 6; pl. 28, figs. 2–6; pl. 29; pl. 30, figs. 2, 3; text figs. 8, 9, 10.

Discocyclina (*Discocyclina*) *harrisoni* VAUGHAN, 1945, Geol. Soc. America Mem. 9, pp. 35–37, pl. 11.

Discocyclina (*Discocyclina*) *crassa* VAUGHAN, 1945, idem, pp. 71, 72, pl. 23, figs. 5–7; pl. 24, figs. 1, 2.

Pseudophragmina (*Proporocyclina*) *marginata* VAUGHAN, 1945, pp. 96, 97, pl. 40, figs. 1, 2.

Discocyclina (*Discocyclina*) *mestieri* COLE & BERMUDEZ (part), 1947, Bull. Amer. Paleont., vol. 31, no. 125, pp. 202, 203, pl. 4, fig. 7; pl. 7, fig. 4 (not pl. 3, fig. 3; pl. 4, figs. 6, 8, 9, 10 which are *D. mestieri* Vaughan).

D. marginata was inadequately described by Cushman from the Eocene of St. Bartholomew. Vaughan (1945) later illustrated an unoriented vertical section and a portion of an oblique equatorial section of a specimen from the type locality of the species which shows some of the equatorial chambers. At this time he incorrectly assigned this species to *Pseudophragmina* (*Proporocyclina*).

At the same time that Cushman described *D.* (*D.*) *marginata*, he proposed another new species, *O. crassa*, from the Eocene of Cuba. Recently, Vaughan (1945) assigned this species to *Discocyclina* (*Discocylina*). In the same paper Vaughan described a new species, *Discocyclina* (*Discocyclina*) *harrisoni*, from the middle Eocene of Barbados.

All three species show an inflated central portion with numerous lateral chambers and rather heavy pillars. Two of them, *D.* (*D.*) *marginata* and *D.* (*D.*) *harrisoni* have the inflated central portion surrounded by a wide, thin rim, but the illustrations of *D.* (*D.*) *crassa* do not show this rim. However, its presence might be suspected by an examination of the margin of the test.

Although the embryonic chambers of *D.* (*D.*) *marginata* were unknown, those of *D.* (*D.*) *crassa* and *D.* (*D.*) *harrisoni* are illustrated adequately by Vaughan, and are virtually identical in the two species.

Thus the literature contains at least three species from different islands, very similar in many respects, but separated so far from each other that two are placed in one genus and one in another.

Gravell in the preliminary study of the specimens from Peñon Seep correctly identified one type with *D.* (*D.*) *marginata*. However, certain doubts existed. Therefore, Cole restudied *D.* (*D.*) *crassa*, *D.* (*D.*) *harrisoni* and *D.* (*D.*) *marginata*. The collection of the late Dr. Alfred Senn from St. Bartholomew contained numerous specimens which could be assigned at once to *D.* (*D.*) *marginata*.

It became clear as the study progressed that Vaughan (1945) had placed *D.* (*D.*) *crassa* and *D.* (*D.*) *harrisoni* in the correct genus, but he incorrectly assigned *D.* (*D.*) *marginata* to the genus *Pseudophragmina*. Vaughan (1945, pl. 40, fig. 1) had an oblique equatorial section of *D.* (*D.*) *marginata* which shows only the peripheral equatorial chambers. The radial chamber walls of these chambers are more or less in alignment, wavy and thin. These are certainly features of *Pseudophragmina*. Moreover, Vaughan believed he saw the annular stolon located on the distal side of the radial chamber walls.

However, examination of equatorial sections of specimens in this collection assigned to *D.* (*D.*) *marginata* shows that the equatorial chambers near the center of the test are of the type possessed by *Discocyclina* s.s. with the annular stolon in the proximal situation (figs. 5, 8, pl. 94). Toward the periphery, however, these chambers become similar in many respects to those of *Pseudophragmina* (fig. 7, pl. 94), but the annular stolon maintains its proximal situation.

D. (*D.*) *crassa* and *D.* (*D.*) *harrisoni* show this same change in the plan of the equatorial chambers from the center of the test toward the periphery, and more nearly oriented equatorial sections in the Senn collection from St. Bartholomew of specimens identified as *D.* (*D.*) *marginata* conform to the pattern developed in the Cuban and Barbados specimens. Therefore, it is easy to understand why Vaughan assigned the type specimens of *D.* (*D.*) *marginata* to the genus *Pseudophragmina*.

Schenck (1929) described a species from California, *Discocyclina californica*, which is identical with the West Indian specimens assigned by us to *D.* (*D.*) *marginata*, a conclusion which Woodring and Daviess (1944, p. 366) have stated would be drawn if the Californian and Cuban species were critically compared.

Certain of the specimens described by Cole and Bermudez (1947) as *D.* (*D.*) *mes-*

tieri Vaughan are not correctly identified. These specimens are *D.* (*D.*) *marginata*, but other specimens are correctly assigned to *D.* (*D.*) *mestieri* Vaughan.

Genus ASTEROCYCLINA Gümbel, 1870

ASTEROCYCLINA HABANENSIS

Cole & Bermudez

Plate 95, figures 1–3, 5; plate 96, figures 3–14

Discocyclina (*Asterocyclina*) *habanensis* COLE & BERMUDEZ, 1947, Bull. Amer. Paleont., vol. 31, no. 125, pp. 204, 205, pl. 18, figs. 1–6.

Test of medium size, stellate with a pronounced, sharply defined, central umbo from which the rays radiate. Many specimens have only four distinct rays, but other specimens have in addition interray areas which connect the principal rays. These specimens may or may not have secondary rays. If secondary rays are developed, they vary in number from one to four. The umbo and the rays are covered with strong, slightly raised papillae with diameters of about 100 μ. The interray areas have slightly smaller papillae with diameters of 40 to 60 μ.

The embryonic chambers consist of a circular to subcircular initial chamber which is partially embraced by a reniform second chamber. There appear to be four periembryonic chambers, two of which lie on each side of the initial chamber, and two of which occur on each side of the second chamber. These chambers have arcuate distal walls.

Measurements of equatorial sections follow:

Equatorial sections of *Asterocyclina habanensis* Cole & Bermudez

Specimen	1	2	3	4	5	6
Diameter	3.2 mm.	4.2+ mm.	4.4+ mm.	3.5 mm.	3.8 mm.	3.5+ mm.
Embryonic chambers:						
Diameter of initial chamber	40 μ	60 μ	60 μ	60 μ	40 μ	40 μ
Diameters of second chamber	20×60 μ	40×80 μ	40×100 μ	40×100 μ	35×60 μ	40×60 μ
Distance across both chambers	60 μ	100 μ	110 μ	100 μ	80 μ	80 μ
Equatorial chambers near periphery						
Interray areas:						
Tangential diameter	20 μ	20 μ	20 μ	—	20 μ	20 μ
Radial diameter	20 μ	30–40 μ	30 μ	—	20 μ	20 μ
Rays:						
Tangential diameter	20 μ	20–30 μ	20–30 μ	20 μ	20 μ	20 μ
Radial diameter	40 μ	60–80 μ	40–60 μ	40–60 μ	20–50 μ	20–40 μ
Number of rays shown	6	4	4	4	4	4

EXPLANATION OF PLATE 100

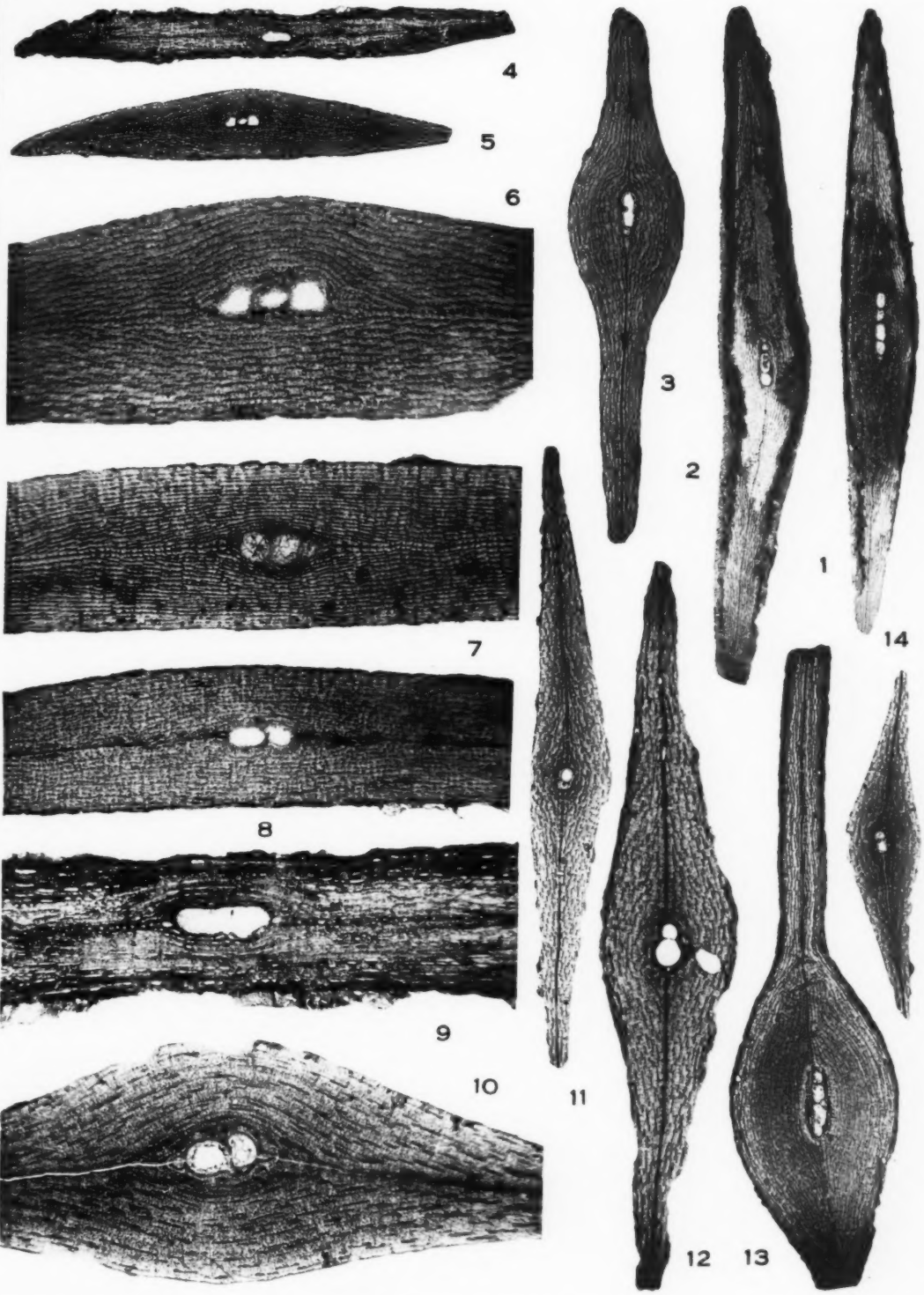
FIGS. *1, 2, 5, 6, 13*—*Pseudophragmina* (*Proporocyclina*) *compacta* Cole & Gravell, n. sp. Vertical sections, *1, 2, 13*, ×12.5; *5*, ×20; *6*, an enlarged portion, ×40, of the specimen illustrated as fig. *5*. (p. 720)

4, 9—*Pseudophragmina* (*Proporocyclina*) *advena* (Cushman). Vertical sections, *4*, ×12.5; *9*, an enlarged portion, ×40, of the same specimen; topotype specimen from the Cane River, Natchitoches, Louisiana, introduced for comparison with *P.* (*P.*) *compacta*. (p. 721)

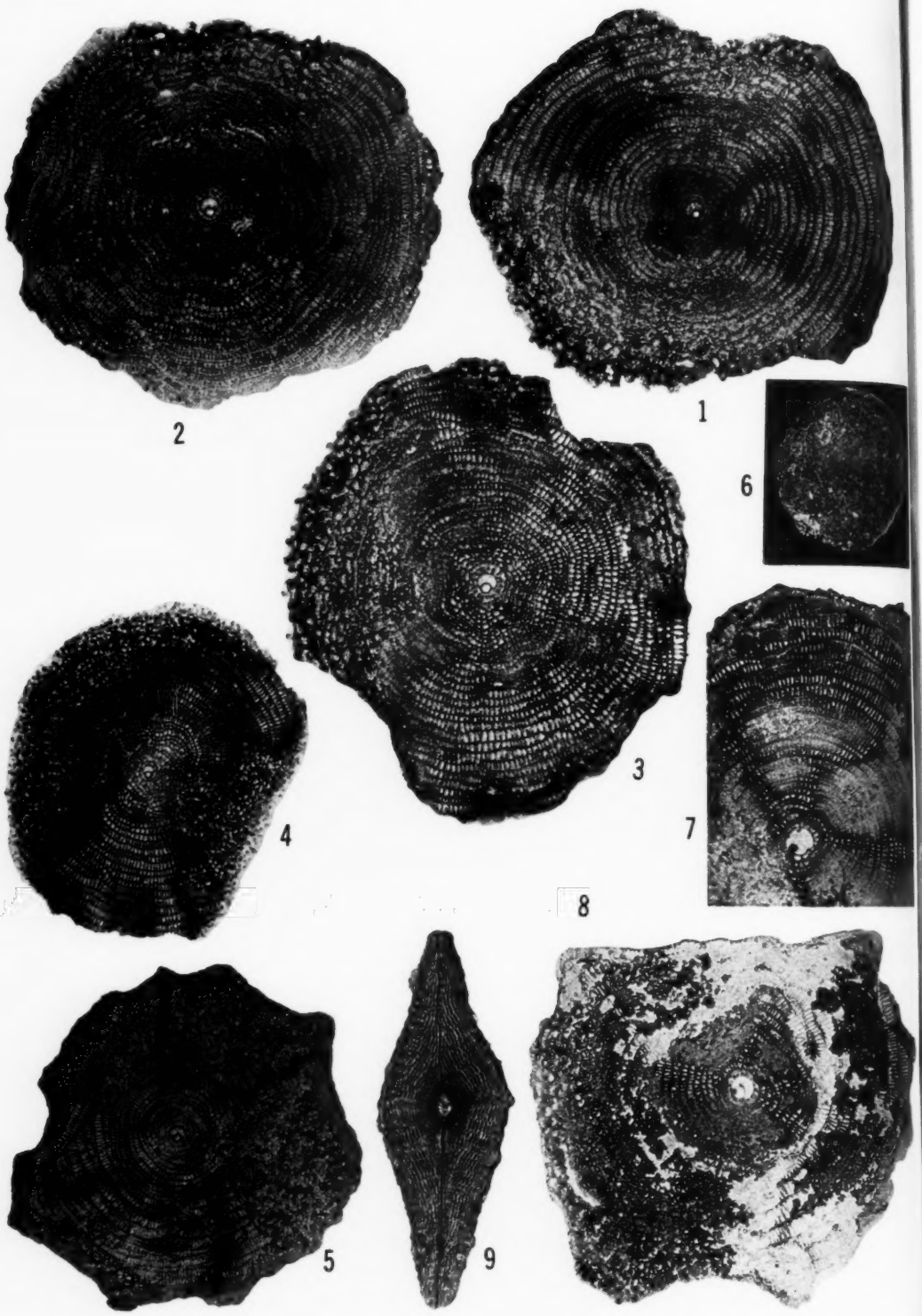
7—*Pseudophragmina* (*Proporocyclina*) *perkinsi* (Vaughan). Portion of a vertical section, ×40, of a specimen from D. K. Palmer sta. 1479, between km. 73.9 and km. 74.6 on the railroad between Nuevitas and Pastelillo, Camaguey Province, Cuba, introduced for comparison with *P.* (*P.*) *compacta*. (p. 721)

8—*Pseudophragmina* (*Proporocyclina*) *cloptoni* (Vaughan). Portion of a vertical section, ×40, of a topotype specimen from Arroyo Guadalupe, 50 miles northwest of La Paz, Lower California, introduced for comparison with *P.* (*P.*) *compacta*. (p. 721)

3, 10–12, 14—*Pseudophragmina* (*Proporocyclina*) *teres* Cole and Gravell, n. sp. Vertical sections, *3, 11, 12, 14*, ×12.5; *10*, an enlarged portion, ×40, of the specimen illustrated as fig. *14*. (p. 725)



Cole and Gravell, Cuban Eocene Foraminifera



Cole and Gravell, Cuban Eocene Foraminifera

The equatorial chambers near the center of the test are small, square with diameters of about 15 μ. These chambers are arranged in a quadrate manner so that the position of the four principal rays is defined in the center of the equatorial section although these rays do not appear on the surface of the test until the edge of the umbonal area is reached. Secondary rays appear in equatorial sections at some distance from the central area.

Measurements of vertical sections follow:

Vertical sections of *Asterocyclina habanensis* Cole & Bermudez

Specimen	1	2	3	4	5	6
Diameter	2.2 mm.	3.+ mm.	2.2 mm.	3.4 mm.	3.4 mm.	3.5 mm.
Thickness	0.64 mm.	0.86 mm.	0.8 mm.	0.7 mm.	0.7 mm.	0.76 mm.
Diameter of umbo	0.9 mm.	0.9 mm.	1.0 mm.	0.7 mm.	0.8 mm.	0.9 mm.
Embryonic chambers:						
Length	40 μ	60 μ	—*	80 μ	40 μ	60 μ
Height	35 μ	50 μ	—	40 μ	25 μ	50 μ
Equatorial layer:						
Height at center	18 μ	10 μ	10 μ	20 μ	10 μ	15 μ
Height at periphery	20 μ	20 μ	20 μ	60 μ	40 μ	50 μ
Lateral chambers:						
Number	15	22	16	15	15	15
Length	60–80 μ	40–60 μ	60–80 μ	60 μ	60–100 μ	60 μ
Height	5 μ	5–8 μ	5 μ	5 μ	5 μ	5 μ
Thickness of roofs and floors	5–10 μ	8–20 μ	10 μ	10 μ	10 μ	10 μ
Surface diameter of pillars	60–80 μ	60–80 μ	80–100 μ	60 μ	60–100 μ	80–120 μ

* Not centered.

The lateral chambers have low, appressed, slit-like cavities between heavy roofs and floors. Between the pillars the lateral chambers are arranged in rather regular tiers, but elsewhere there is considerable overlapping from one tier to the next adjacent one.

Heavy pronounced pillars occur in the central umbonate area and scattered smaller pillars are found in the peripheral zone.

Discussion.—There are some minor differences between the type specimens of this species and the specimens in the collection under discussion. The type specimen has stronger, more elevated and fewer papillae on the umbo than do the specimens from Peñon Seep. Moreover, the type specimen does not have papillae on the interray areas. The vertical sections of the specimens from the type locality have fewer lateral chambers and less frequent but heavier pillars than do the specimens from Peñon Seep. However, the shape, arrangement and distribution of the external and internal features in the specimens from the two localities are such that one would hesitate to create two distinct species.

A vertical section of a topotype specimen of *A. aster* Woodring (fig. 9, pl. 101) is illustrated for comparison with the Cuban species of *Asterocyclina*. The roofs and floors of the lateral chambers of *A. aster* are much thinner than those of *A. habanensis*.

EXPLANATION OF PLATE 101

FIGS. *1–3*—*Pseudophragmina* (*Proporocyclina*) *convexicamerata* Cole & Gravell, n. sp. Equatorial sections, ×20. (p. 721)

4, 5—*Pseudophragmina* (*Proporocyclina*) *psila* (Woodring). Equatorial sections, ×20. (p. 725)

6–8—*Pseudophragmina* (*Proporocyclina*) *teres* Cole & Gravell, n. sp. *6*, external view, ×5, of the holotype, Cole collection No. 408; *7, 8*, equatorial sections, ×20. (p. 725)

9—*Asterocyclina aster* Woodring. Vertical section, ×20, of a topotype specimen from Cal. Inst. Tech. Loc. 595, south slope of western Santa Ynez Range, Santa Barbara County, California, west side of Canada de los Sauces 1.2 miles above coast. (p. 717)

ASTEROCYCLINA MONTICELLENSIS
Cole & Ponton
Plate 95, figure 4; plate 96, figure 2;
plate 97, figures 1–11

Discocyclina (*Asterocyclina*) *monticellensis* COLE & PONTON, 1934, Amer. Midland Nat., vol. 15, pp. 141, 142, pl. 2, figs. 6–11; —— COLE, 1944, Florida Geol. Survey Bull. 26, pp. 76–79, pl. 1, fig. 8; pl. 2, fig. 11; pl. 8, fig. 23; pl. 13, fig. 5; pl. 23, figs. 1–12; Cole, 1945, idem, Bull. 28, pp. 122, 123, pl. 21, figs. 1–13.

Tests small, stellate, central portion inflated, rays peripherally developed, projecting as short, pointed arms, five to eight in number, from their junction with the central area which shows no reflection of the rays. There is an apical crown of larger papillae with diameters of about 140 μ beyond which there are smaller papillae with diameters of about 60 μ. The arms and a narrow peripheral zone appears to be without papillae.

The embryonic chambers are bilocular with a spherical initial chamber with an internal diameter of about 60 μ and a reniform second chamber with internal diameters of about 40 by 100 μ.

The stellate pattern of the test is shown by the arrangement of the equatorial chambers. Chambers in the interray area have radial diameters of about 30 μ and tangential diameters of about 20 μ. Chambers in the center of the rays have radial diameters of about 40 μ and tangential diameters of about 20 μ.

Measurements of vertical sections follow:

The lateral chambers are aligned in regular tiers and have a rectangular shape. The chamber cavity is low, open, distinct. The floors and roofs are either straight or very slightly convex toward the periphery.

Large, strong pillars occur normally over the embryonic chambers with smaller pillars scattered in the areas beyond the zone of the large pillars.

Discussion.—There is certain individual variation between specimens assigned to this species. Certain specimens (pl. 97, fig. 3) are compressed whereas others are inflated (pl. 97, fig. 5). Specimens from Florida show the same features, however. The specimen from Peñon Seep (pl. 97, fig. 8) should be compared with the vertical section (pl. 2, fig. 9) illustrated by Cole and Ponton (1934) and the Cuban specimen (pl. 97, fig. 1) should be compared with the Floridian specimen (pl. 23, fig. 1) illustrated by Cole (1944).

ASTEROCYCLINA PENONENSIS Cole and
Gravell, n. sp.
Plate 96, figure 1; plate 98, figures 1–8

Test medium size, strongly inflated with a narrow rim on which five or six short arms are developed. The arms are entirely confined to the rim and do not appear on the umbonate portion of the test. The inflated central portion is thickly and regularly studded with small, slightly raised papillae which continue outward on the arms. The rim has a few scattered papillae.

Vertical sections of *Asterocyclina monticellensis* Cole & Ponton

Specimen	1	2	3
Diameter	1.7 mm.	1.4+ mm.	1.4+ mm.
Thickness	0.98 mm.	0.9 mm.	0.72 mm.
Embryonic chambers:			
Length	60 μ	120 μ	60 μ
Height	40 μ	75 μ	60 μ
Equatorial layer:			
Height at center	15 μ	20 μ	15 μ
Height at periphery	40 μ	40 μ	20 μ
Lateral chambers:			
Number	16	15	15
Length	60–80 μ	60–80 μ	50 μ
Height	20 μ	15 μ	10 μ
Thickness of floors and roofs	15 μ	20 μ	10 μ
Surface diameter of pillars	80–200 μ	60–100 μ	100–180 μ

The embryonic chambers are either nephrolepidine or eulepidine in type. There is considerable variation in total size of these chambers from specimen to specimen. The embryonic chambers are surrounded by a complete ring of rather large, more or less square periembryonic chambers.

Measurements of equatorial sections follow:

Moderate size pillars are scattered irregularly throughout the umbonate area. Small pillars occur in the rim.

Comparisons.—Externally, this species resembles *Asterocyclina franksi* Vaughan (1945, p. 43) from the middle Eocene of Barbados. Unfortunately, *A. franksi* is known only by its external appearance and a few of the characteristics of the equatorial chambers. As the classification of these forms depend largely on the internal features, it would not be safe to assign the Peñon Seep specimens to this species.

Equatorial sections of *Asterocyclina penonensis* Cole & Gravell, n. sp.

Specimen	1	2	3	4	5
Diameter	2.9 mm.	3.2 mm.	3.2 mm.	3.2+ mm.	3.2 mm.
Embryonic chambers:					
Diameters of initial chamber	80×180 μ	80×160 μ	120×180 μ	140×180 μ	260×280 μ
Diameters of second chamber	140×300 μ	120×320 μ	120×260 μ	120×240 μ	60×560 μ
Distance across both chambers	240 μ	220 μ	260 μ	280 μ	340 μ
Thickness of outer wall	10 μ	10 μ	10 μ	8 μ	5 μ
Equatorial chambers:					
Near center					
Tangential diameter	20 μ	20 μ	20 μ	20 μ	20 μ
Radial diameter	20 μ	25 μ	25 μ	20 μ	40 μ
Near periphery (interray)					
Tangential diameter	20 μ	20 μ	25 μ	25 μ	20 μ
Radial diameter	40 μ	40 μ	50 μ	100 μ	50–60 μ
Near periphery (ray)					
Tangential diameter	30 μ	20–30 μ	20–30 μ	20–30 μ	20 μ
Radial diameter	60 μ	40–80 μ	55–60 μ	40–80 μ	50–60 μ

Measurements of vertical sections follow:

Vertical sections of *Asterocyclina penonensis* Cole & Gravell, n. sp.

Specimen	1	2	3	4	5
Diameter	4.3 mm.	4.1 mm.	3.2 mm.	4.1 mm.	3.7 mm.
Thickness	1.56 mm.	1.4 mm.	1.1 mm.	1.16 mm.	1.26 mm.
Diameter of umbo	2.8 mm.	2.0 mm.	2.0 mm.	2.4 mm.	1.8 mm.
Width of rim	0.8 mm.	1.3 mm.	0.5 mm.	1.0 mm.	1.5 mm.
Thickness of rim	0.2 mm.	0.5 mm.	0.2 mm.	0.2 mm.	0.32 mm.
Embryonic chambers:					
Length	400 μ	280 μ	340 μ	300 μ	260 μ
Height	120 μ	220 μ	120 μ	160 μ	160 μ
Equatorial layer:					
Height at center	35 μ	20 μ	20 μ	20 μ	20 μ
Height at periphery	60 μ	100 μ	70 μ	40 μ	160 μ
Lateral chambers:					
Number	20	19	16	17	18
Length	80 μ	60–100 μ	80–100 μ	50–80 μ	60–80 μ
Height	20 μ	18 μ	15 μ	15 μ	10 μ
Thickness of floors and roofs	20 μ	10–15 μ	20 μ	15 μ	15 μ
Surface diameter of pillars	80–120 μ	100 μ	80–100 μ	60–120 μ	120 μ

The lateral chambers are arranged in regular tiers. The chamber cavities are open, rectangular in shape with rather heavy roofs and floors.

Genus PSEUDOPHRAGMINA H. Douvillé, 1923
Subgenus PROPOROCYCLINA Vaughan and Cole, 1940
PSEUDOPHRAGMINA (PROPOROCYCLINA) COMPACTA Cole & Gravell, n. sp.
Plate 95, figure 6; plate 99, figures 6–8; plate 100, figures 1, 2, 5, 6, 13

Test compressed, lenticular, sloping regularly from the center to the periphery Surface smooth, unornamented.

The initial embryonic chamber is circular to subcircular in shape as viewed in equatorial section. The second embryonic chamber is reniform and strongly embraces the initial chamber. The outer wall of the embryonic chambers is thin. There is a complete ring of periembryonic chambers.

In many specimens there is more than one set of embryonic chambers, the number of which may be two, three or four. Measurements of the individual embryonic chambers in a specimen with a set of four follow:

Diameter of initial chamber	Diameter of second chamber	Distance across both chambers
120×120μ	150×300μ	280μ
170×160μ	180×380μ	360μ
150×160μ	120×340μ	290μ
120×120μ	180×320μ	310μ

Measurements of equatorial sections with only one set of embryonic chambers follow:

Equatorial sections of *Pseudophragmina* (*Proporocyclina*) *compacta* Cole & Gravell, n. sp.

Specimen	1	2	3
Diameter	5.0 mm.	5.4 mm.	3.6 mm.
Embryonic chambers:			
Diameters of initial chamber	80×90 μ	120×130 μ	60×65 μ
Diameters of second chamber	120×220 μ	110×340 μ	90×155 μ
Distance across both chambers	210 μ	240 μ	160 μ
Equatorial chambers:			
Radial diameter	30 μ	40 μ	20 μ
Tangential diameter	20 μ	20 μ	20 μ

The annuli are narrow. The annular walls are distinct, but the radial walls are imperfectly developed. These radial walls are incomplete, irregular and wavy, but aligned. The annular stolon is located on the distal side. Measurements of vertical sections follow:

Vertical sections of *Pseudophragmina* (*Proporocyclina*) *compacta* Cole & Gravell, n. sp.

Specimen	1	2	3	4
Diameter	7.7 mm.	5.4 mm.	7.8 mm.	7.0 mm.
Thickness	1.08 mm.	0.8 mm.	1.0 mm.	0.92 mm.
Embryonic chambers:				
Length	460 μ	380 μ	360 μ	760 μ*
Height	100 μ	100 μ	90 μ	120 μ
Equatorial layer:				
Height at center	7 μ	6 μ	8 μ	5 μ
Height at periphery	40 μ	20 μ	20 μ	20 μ
Lateral chambers:				
Number	20	14	19	16
Length	40–60 μ	40–80 μ	40–130 μ	50–120 μ
Height	5 μ	5 μ	5 μ	5 μ
Thickness of roofs and floors	20–30 μ	20 μ	20 μ	10–20 μ

* Double embryonic chambers.

The lateral chambers are not arranged in definite tiers. The chamber cavities are very low, appressed, slit-like between heavy floors and roofs.

Pillars are not present.

Comparisons.—This new species has an equatorial section which resembles that of *P. (P.) advena* (Cushman). However, the vertical sections are not at all similar to those of *P. (P.) advena* (figs. 4, 9, pl. 100) as the lateral chamber cavities are lower and more appressed, the floors and roofs are thinner and there are more lateral chambers to a tier.

In vertical section this species does have a resemblance to *P. (P.) cloptoni* (fig. 8, pl. 100) and *P. (P.) perkinsi* (fig. 7, pl. 100). The general structure is, however, much coarser than either of the named species, and in consequence there are fewer lateral chambers to a tier.

The embryonic chambers of this new species are frequently multiple (fig. 6, pl. 95), a feature which Vaughan (1929, pl. 5, figs. 4, 5) found in *P. (P.) cloptoni*. However, vertical sections are sufficiently distinct to allow separation of specimens from Peñon Seep from those described from Mexico.

PSEUDOPHRAGMINA (PROPOROCYCLINA) CONVEXICAMERATA Cole & Gravell, n. sp.
Plate 101, figures 1–3; plate 102, figures 12–19

Test small, evenly lenticular. Surface ornamented by small, raised papillae arranged in concentric circles. The papillae have surface diameters of about 60 μ and are separated from each other by a distance of 40 to 60 μ. The papillae are equally well developed over the entire surface of the test.

The embryonic chambers are small and nephrolepidine in type. There is a complete ring of periembryonic chambers surrounding the embryonic chambers.

Measurements of equatorial sections follow:

Equatorial sections of *Pseudophragmina (Proporocyclina) convexicamerata* Cole & Gravell, n. sp.

Specimen	1	2	3	4
Diameter	3.1 mm.	3.2 mm.	3.2 mm.	3.1 mm.
Embryonic chambers:				
Internal diameter of initial chamber	60 μ	50 μ	60 μ	50 μ
Internal diameters of second chamber	100×140 μ	80×120 μ	100×130 μ	80×90 μ
Distance across both chambers	120 μ	120 μ	120 μ	100 μ
Thickness of outer wall	4 μ	5 μ	5 μ	4 μ
Equatorial chambers:				
Radial diameter				
Near center	20 μ	25 μ	20 μ	20 μ
At periphery	60 μ	80 μ	80 μ	80 μ
Tangential diameter				
Near center	20 μ	20 μ	20 μ	20 μ
At periphery	40 μ	40 μ	40 μ	40 μ

The radial chamber walls are complete, in alignment and very slightly wavy. The annular stolon is in a distal situation.

Measurements of vertical sections made from a series of specimens of this interesting new species are given in the table below:

Vertical sections of *Pseudophragmina (Proporocyclina) convexicamerata* Cole & Gravell, n. sp.

Specimen	1	2	3	4
Diameter	2.8+ mm.	3.+ mm.	2.7+ mm.	2.24+ mm.
Thickness	1.0 mm.	1.0 mm.	0.86 mm.	0.7 mm.
Embryonic chambers:				
Internal length	120 μ	—	70 μ	40 μ
Internal height	30 μ	—	35 μ	30 μ
Equatorial layer:				
Internal height at center	20 μ	15 μ	10 μ	10 μ
Internal height at periphery	20 μ	20 μ	20 μ	15 μ
Lateral chambers:				
Number on each side of equatorial layer	14	15	12	9
Length	100–120 μ	60–100 μ	40–160 μ	60–100 μ
Height	20 μ	10–20 μ	20 μ	20 μ
Thickness of floors and roofs	20 μ	15–30 μ	20 μ	20 μ
Surface diameter of pillars	40–80 μ	40–80 μ	60 μ	60 μ

The lateral chambers are arranged more or less in tiers, but there is considerable overlapping from one tier to the next adjacent one. The chamber cavities are low with the floors and roofs about equal in thickness to the height of the chamber cavities. Most specimens have the floors and roofs of the lateral chambers convex toward the periphery so that the lateral chambers are arcuate in shape. This condition is especially noticeable in the lateral chambers adjacent to the equatorial layer. Small, slender pillars are irregularly distributed through the vertical sections.

Comparisons.—This new species externally and in equatorial section resembles *P.* (*P.*) *perpusilla* (Vaughan) (1929, p. 9) from the Guayabal formation (Cole, 1927) of Mexico. Therefore, a new vertical section of *P.* (*P.*) *perpusilla* was prepared and is illustrated as figure 11, plate 102. *P.* (*P.*) *perpusilla* is a thinner form with relatively few lateral chambers on each side of the embryonic apparatus.

PSEUDOPHRAGMINA (PROPOROCYCLINA) CUSHMANI (Vaughan)

Plate 99, figures 1–5

Discocyclina cushmani VAUGHAN, 1929, Proc. U. S. Nat. Museum, vol. 76, art. 3, pp. 11–13, pl. 3, figs. 1–4.

Pseudophragmina (*Proporocyclina*) *cushmani* VAUGHAN, 1945, Geol. Soc. America Mem. 9, pp. 94, 95, pl. 38, figs. 1–3*a*; —— COLE & BERMUDEZ, 1947, Bull. Amer. Paleont., vol. 31, no. 125, pp. 18, 19, pl. 6, figs. 1–4; pl. 7 fig. 9.

In the description of a fauna from a roadcut at Finca "La Coronela" on the road from Habana to Rancho Boyeros, Habana Province, Cole and Bermudez (1947) report this species among others. This Cuban occurrence was the first to be recorded for this species outside of its type area in the Mecapala Hills southwest of Tantoyuca, State of Vera Cruz, Mexico.

The equatorial sections of this species are not distinctive, but the vertical sections are. There is a small, sharp umbo at the center which is surrounded by a wide, thin, flat rim.

The original description and illustration of the external features of this species is excellent. Subsequently, Vaughan published photomicrographs of additional thin sections which show the internal structures in a most adequate manner. The specimens in the present collection agree at all points with the type specimens from Mexico.

Measurements made from thin sections of typical specimens in the present collection follow:

Vertical sections of *Pseudophragmina* (*Proporocyclina*) *cushmani* (Vaughan)

Specimen	1	2	3
Diameter	5.48 mm.	5.2 mm.	5.2 mm.
Diameter of umbo	1.1 mm.	1.6 mm.	1.2 mm.
Width of flange	2.1 mm.	1.8 mm.	1.9 mm.
Thickness of umbo	1.1 mm.	1.3 mm.	1.2 mm.
Thickness of flange near umbo	0.46 mm.	0.6 mm.	0.6 mm.
Thickness of flange near periphery	0.3 mm.	0.5 mm.	0.4 mm.
Embryonic chambers:			
Length	200 μ	180 μ	160 μ
Height	60 μ	80 μ	90 μ
Equatorial layer:			
Height at center	5 μ	4 μ	3 μ
Height at periphery	20 μ	20 μ	17 μ
Lateral chambers on each side of equatorial layer:			
In umbo	14	16	16
In flange near umbo	6	9	7
In flange near periphery	1	3	2
Lateral chambers:			
Length (umbonal, peripheral)	120 μ	100–120 μ	90 μ
Height (umbonal, peripheral)	20 μ	15 μ	5–15 μ
Thickness of roofs and floors	20 μ	20 μ	20 μ
Surface diameter of pillars	40–60 μ	40 μ	40–70 μ

Discussion.—There is little doubt that the vertical section of "*Orthophragmina*" = *Asterocyclina antillea* published by Cushman (1919, pl. 2, fig. 3, lower left corner) as one of the type illustrations of this species represents *P.* (*P.*) *cushmani.*

PSEUDOPHRAGMINA (PROPOROCYCLINA) PENONENSIS Cole & Gravell, n. sp.
Plate 103, figures 2–9

Test slightly selliform, composed of three distinct portions, a depressed central area, a broadly rounded elevated portion and a wide, thin rim. Scattered, and rather inconspicuous papillae occur in the central area, but large, closely spaced, prominent papillae occur on the elevated, ring-shaped area which surrounds the central depression. The outer rim has a few, widely scattered small papillae.

The embryonic chambers are large, thin-walled, with the second chamber enclosing the initial chamber except along the common boundary of the chambers. A ring of periembryonic chambers completely surrounds the embryonic chambers except for a short distance near the middle of the common boundary between the initial and the second chamber where periembryonic chambers do not occur.

Measurements of equatorial sections follow:

The lateral chambers near the equatorial plane have slit-like cavities between very thick roofs and floors. Near the periphery the lateral chambers have more open cavities and the floors and roofs are not so thick. The lateral chambers are not arranged in regular tiers.

The ring-like elevated portion of the test has more layers of lateral chambers than does the depressed central portion. Moreover, the lateral chambers in the elevated portion have slightly thicker roofs and floors than do those in the central area.

Heavy pillars are concentrated in the elevated portion of the test. Scattered pillars occur in both the depressed, central portion and in the marginal rim.

Comparisons.—In cross-sectional form this species resembles *Orthophragmina umbilicata* Deprat (1905, p. 497, pl. 16, figs. 2–11) from the Eocene of New Caledonia. Fortunately, Deprat gives an excellent illustration of the equatorial chambers of this species. They prove that *O. umbilicata* should be placed in the genus *Discocyclina.*

Cole (1942, p. 46) identified certain specimens from the lower middle Eocene of Florida from Florida Oil Discovery Company's Cedar Keys well No. 2 with *Pseudophragmina* (*Proporocyclina*) *zaragosensis* (Vaughan) from the Eocene of Mexico. Later, Cole (1944, p. 81) created a new species *P.* (*P.*) *cedarkeysensis* for these specimens. In this same publication, but from the St. Mary's River Oil Corporation, Hilliard Turpentine Company well No. 1, Cole (p. 84) described another new species under the name *P.* (*P.*) *hannai.*

Equatorial sections of *Pseudophragmina* (*Proporocyclina*) *penonensis* Cole & Gravell, n. sp.

Specimen	1	2
Diameter	5.0 mm.	6.5 mm.
Embryonic chambers:		
Internal diameters of initial chamber	240×280 μ	220×240 μ
Internal diameters of second chamber	400×600 μ	500×540 μ
Distance across both chambers	460 μ	500 μ
Thickness of outer wall	15 μ	10 μ
Equatorial chambers:		
Near center		
Radial diameter	60 μ	40 μ
Tangential diameter	40 μ	40 μ
Near periphery		
Radial diameter	50 μ	80 μ
Tangential diameter	40 μ	20 μ

The radial chamber walls are rather well-developed, slightly wavy and in alignment. The annular stolon is located on the distal side.

Measurements of vertical sections are shown at the top of the next page.

Vertical sections of *Pseudophragmina* (*Proporocyclina*) *penonensis* Cole & Gravell, n. sp.

Specimen	1	2	3	4
Total diameter		5.6+ mm.	9.2 mm.	8.+ mm.
Umbonal diameter	3.8 mm.	3.9 mm.	4.4 mm.	5.0 mm.
Width of flange	missing	1.0+ mm.	2.8 mm.	1.6+ mm.
Thickness at central depression	0.84 mm.	0.94 mm.	1.04 mm.	1.08 mm.
Thickness of elevated portion surrounding depressed center	0.92 mm.	1.1 mm.	1.4 mm.	1.6 mm.
Embryonic chambers:				
Internal length	440 μ	520 μ	540 μ	500 μ
Internal height	160 μ	200 μ	200 μ	220 μ
Thickness of outer wall	20 μ	20 μ	20 μ	20 μ
Equatorial layer:				
Internal height at center	3 μ	5 μ	6 μ	6 μ
Internal height at periphery	6 μ	10 μ	25 μ	20 μ
Lateral chambers:				
Number on each side of equatorial layer				
At center	12	12	13	14
In the elevated portion	14	15	17	23
Internal length	60–100 μ	60–100 μ	80–100 μ	80–140 μ
Internal height	20 μ	15 μ	10 μ	20 μ
Thickness of roofs and floors	20 μ	20 μ	20 μ	20 μ
Pillars:				
Surface diameter	100 μ	100–120 μ	100 μ	120 μ

The Floridian specimens have been restudied, and it is apparent the entire series represents only one species, here designated *P.* (*P.*) *cedarkeysensis* with *P.* (*P.*) *hannai* a synonym.

Certain of the Floridian specimens, particularly those formerly known as *P.* (*P.*) *hannai* possess a slightly depressed central area and have a bordering rim. A vertical section of one of these is illustrated as figure 1, plate 103.

Some of the Cuban specimens have a barely depressed central area. This form is illustrated by the vertical section figure 2, plate 103. Therefore, one extreme of the Cuban form is very similar in external shape to that of certain of the Floridian specimens.

If external shape only were considered, it would be entirely reasonable to assign the Floridian and Cuban specimens to the same species. Internally, however, there appear to be differences by which the two types can be separated even with specimens of the same external shape.

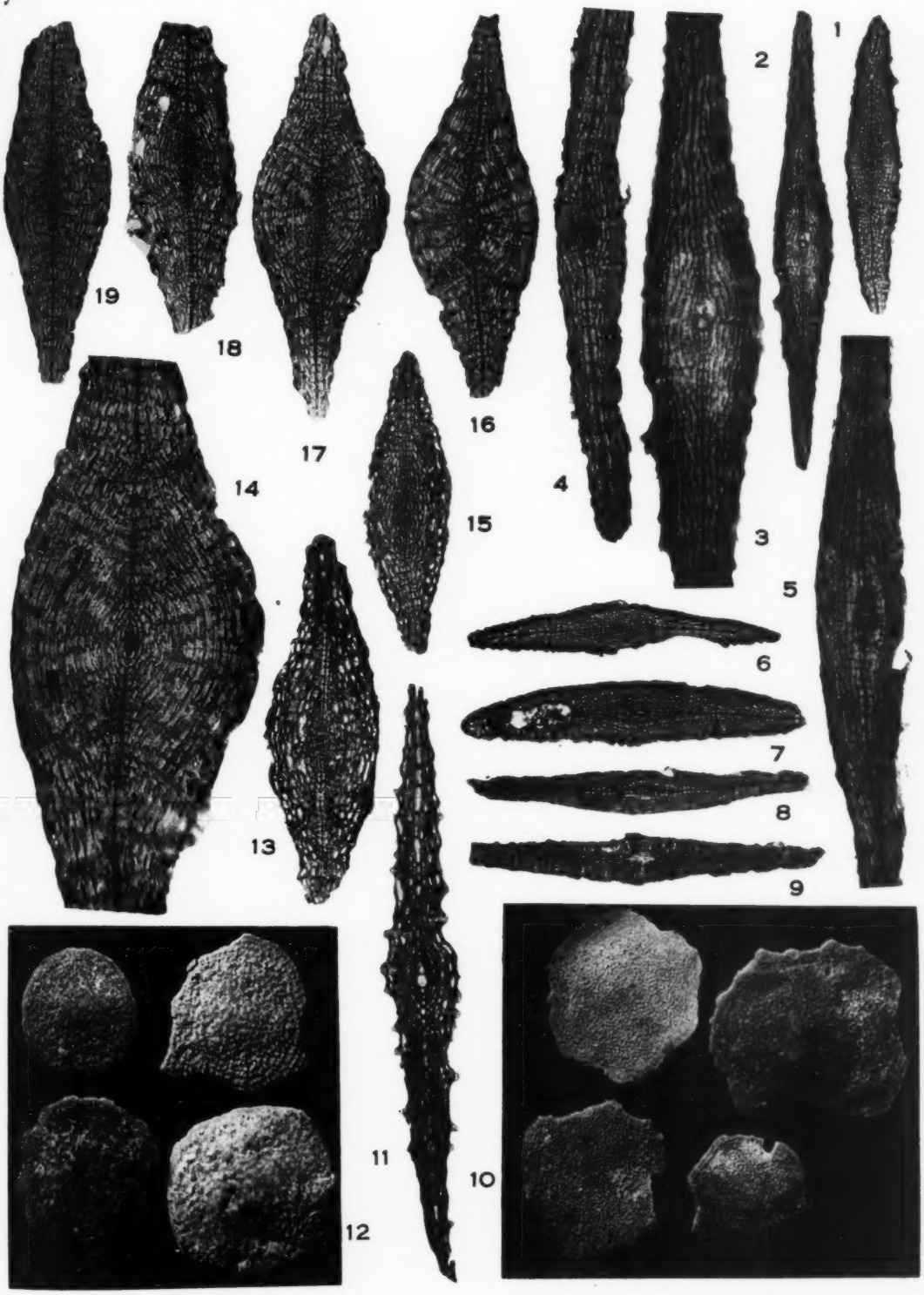
In equatorial section the embryonic chambers of *P.* (*P.*) *penonensis* are twice as large as those of *P.* (*P.*) *cedarkeysensis*, and the radial walls of the equatorial chambers of *P.* (*P.*) *penonensis* are much better developed than those of *P.* (*P.*) *cedarkeysensis*. In vertical section the lateral chambers are arranged more regularly and have thinner floors and roofs in *P.* (*P.*) *penonensis* than in *P.* (*P.*) *cedarkeysensis*. However, there are many aspects of the vertical sections which appear very similar, if not identical.

Explanation of Plate 102

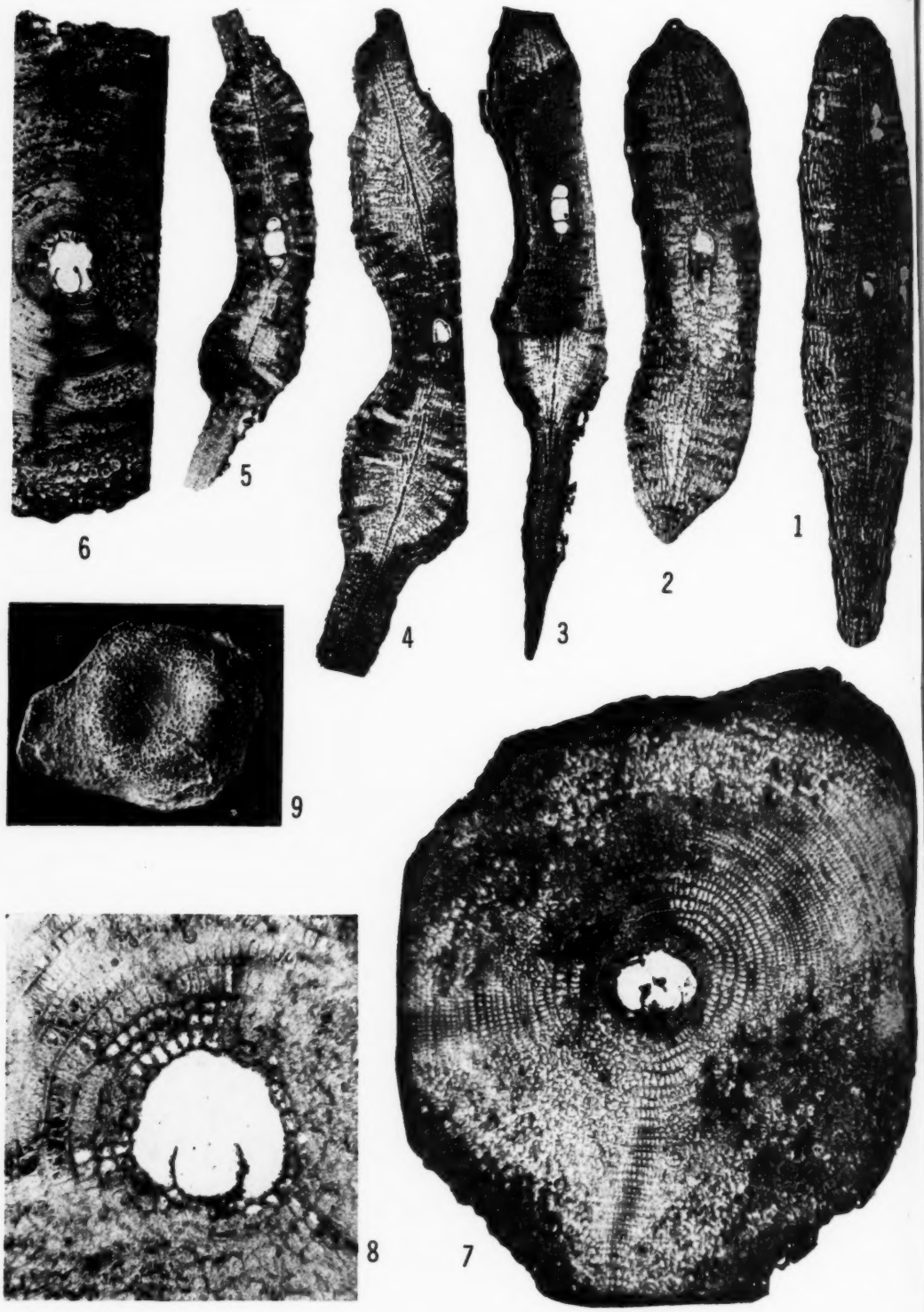
FIGS. *1–10*—*Pseudophragmina* (*Proporocyclina*) *psila* (Woodring). *1–9*, vertical sections, *1*, *2*, *6–9*, ×20; *3–5*, ×40; *4*, *5*, *8*, *9*, topotype specimens from Cal. Inst. Tech. Loc. 595, south slope of western Santa Ynez Range, Santa Barbara County, California, west side of Canada de los Sauces 1.2 miles above coast, introduced for comparison with the Cuban specimens; *10*, external views, ×10, of 4 specimens. (p. 725)

11—*Pseudophragmina* (*Proporocyclina*) *perpusilla* (Vaughan). Vertical section, ×40, from a specimen from the type locality of the Guayabal formation, introduced for comparison. (p. 722)

12–19—*Pseudophragmina* (*Proporocyclina*) *convexicamerata* Cole & Gravell, n. sp. *12*, external views, ×10, of 4 specimens; upper left specimen, holotype, Cole collection No. 411; *13–19*, vertical sections, ×20, except *14*, ×40. (p. 721)



Cole and Gravell, Cuban Eocene Foraminifera



Cole and Gravell, Cuban Eocene Foraminifera

The vertical sections of this new species also resemble those of *Discocylina* (*Discocyclina*) *grimsdalei* Vaughan and Cole, known from Trinidad and Barbados. However, *D.* (*D.*) *grimsdalei* is correctly assigned generically and, therefore, is distinct from the specimens under discussion.

PSEUDOPHRAGMINA (PROPOROCYCLINA) PSILA (Woodring)
Plate 101, figures 4, 5; plate 102, figures 1–10

Discocyclina psila WOODRING, 1930, Trans. San Diego Soc. Nat. Hist., vol. 6, pp. 148–151, pl. 14, figs. 2, 4–6; pl. 15, fig. 17; — VAUGHAN, 1936, Jour. Paleontology, vol. 10, pp. 255, 256, pl. 42, figs. 7, 8.
Pseudophragmina (*Proporocyclina*) *psila* VAUGHAN, 1945, Geol. Soc. America, Mem. 9, pp. 65, 104, 106, 115.

Test small, compressed, thin, evenly lenticular without an umbo. Surface ornamentation consists of closely-spaced, slightly raised, papillae evenly distributed over the entire surface.

The embryonic chambers are small and nephrolepidine in type. These chambers are completely surrounded by a ring of periembryonic chambers with about ten chambers in the ring.

Measurements of equatorial sections follow:

The radial chamber walls are well developed, in alignment and slightly wavy. The annular stolon is on the distal side of the radial chamber walls.

Measurements of vertical sections are shown at top of next page.

The cavities of the lateral chambers are slit-like between thick roofs and floors. The lateral chambers are not in regular tiers. Small, slender pillars are irregularly scattered throughout the entire length of the vertical sections.

Discussion.—Through the courtesy of Drs. Wendell P. Woodring and Charles Merriam, a generous supply of topotype specimens were made available for study. Two vertical sections and enlarged portions of two others, made from the topotype specimens, are illustrated for comparison with the specimens from Peñon Seep. It is impossible to separate the California specimens from those found in Cuba.

PSEUDOPHRAGMINA (PROPOROCYCLINA) TERES Cole & Gravell, n. sp.
Plate 100, figures 3, 10–12, 14; plate 101, figures 6–8

Test either inflated lenticular or with a distinct umbo bordered by a wide gently sloping rim. Surface smooth, unornamented, but with irregular light areas scattered over

Equatorial sections of *Pseudophragmina* (*Proporocyclina*) *psila* (Woodring)

Specimen	1	2	3
Diameter	1.9 mm.	2.4 mm.	2.8 mm.
Embryonic chambers:			
Diameters of initial chamber	40 μ	35 μ	40 μ
Diameters of second chamber	30×60 μ	35×65 μ	40×100 μ
Distance across both chambers	70 μ	70 μ	80 μ
Equatorial chambers:			
Near center			
Radial diameter	20 μ	25 μ	25 μ
Tangential diameter	20 μ	20 μ	20 μ
Near periphery			
Radial diameter	70 μ	60 μ	50 μ
Tangential diameter	20 μ	20 μ	20 μ

EXPLANATION OF PLATE 103

FIG. *1*—*Pseudophragmina* (*Proporocyclina*) *cedarkeysensis* Cole. Vertical section, ×20, of a specimen, from a depth of 1745–1752 feet from the St. Mary's River Oil Corporation, Hilliard Turpentine Company well No. 1, located in Nassau County, Florida, introduced for comparison with *P.* (*P.*) *penonensis*. (p. 723)
2–9—*Pseudophragmina* (*Proporocyclina*) *penonensis* Cole and Gravell, n. sp. *2–5*, vertical sections, *2*, ×20; *3*, ×12.5; *4*, ×20; *5*, ×12.5; *6–8*, equatorial sections, *6*, ×12.5; *7*, ×20; *8*, ×40; *9*, external view, ×5, of the holotype, Cole collection No. 406. (p. 723)

Vertical sections of *Pseudophragmina* (*Proporocyclina*) *psila* (Woodring)

Specimen	1	2	3	4
Diameter	2.14 mm.	2.4 mm.	2.6 mm.	3.3 mm.
Thickness	0.42 mm.	0.4 mm.	0.5 mm.	0.46 mm.
Embryonic chambers:				
Length	30 μ	40 μ	—	40 μ
Height	25 μ	25 μ	—	40 μ
Equatorial layer:				
Height at center	10 μ	10 μ	10 μ	10 μ
Height at periphery	14 μ	14 μ	14 μ	10 μ
Lateral chambers				
Number	6	6	9	8
Length	60 μ	40 μ	40–60 μ	40–80 μ
Height	10 μ	15 μ	10 μ	10 μ
Thickness of floors and roofs	20 μ	20 μ	20 μ	20 μ
Surface diameter of pillars	20 μ		30 μ	40 μ

a darker background. These light areas undoubtedly represent the position of the lateral chambers.

The initial chamber is circular with an internal diameter of about 130 μ. The second chamber is reniform with internal diameters of about 110 by 260 μ. The distance across both chambers is about 240 μ. The outer wall is thin with a thickness of about 5 μ. The embryonic chambers are surrounded by a complete ring of periembryonic chambers.

The equatorial chambers gradually increase in radial diameter as the periphery of the test is approached. Peripheral equatorial chambers have a radial diameter as much as 160 μ, although the average radial diameter is about 100 μ. The tangential diameter of these chambers is 30 to 40 μ. The radial chamber walls are complete, distinct, slightly wavy and aligned. The annular stolon is located on the distal side of the radial chamber walls.

Measurements of vertical sections follow:

Vertical sections of *Pseudophragmina* (*Proporocyclina*) *teres* Cole & Gravell, n. sp.

Specimen	1	2	3	4	5
Diameter	4.0 mm.	5.68 mm.	6.+ mm.	7.0 mm.	5.2 mm.
Thickness	0.9 mm.	0.92 mm.	1.4 mm.	1.0 mm.	1.0 mm.
Shape	inflated lenticular	sharp umbo flat rim	sharp umbo flat rim	inflated lenticular	inflated lenticular
Embryonic chambers:					
Length	250 μ	480 μ	400 μ	240 μ	300 μ
Height	120 μ	100 μ	160 μ	120 μ	180 μ
Equatorial layer:					
Height at center	5 μ	—	7 μ	7 μ	7 μ
Height at periphery	10 μ	—	15 μ	10 μ	9 μ
Lateral chambers:					
Number	12	12	14	15	12
Length	40–120 μ	20–240 μ	40–220 μ	40–200 μ	40–160 μ
Height	5 μ	5 μ	7 μ	5 μ	7 μ
Thickness of floors and roofs	20–40 μ	20–40 μ	20–60 μ	20–60 μ	20–40 μ

The lateral chambers are not arranged in regular tiers. Their distribution is very irregular so that it is difficult to decide on the actual number of layers of lateral chambers. The number given in the table is the best approximation that can be made. The chamber cavities are low, appressed between very thick roofs and floors.

Pillars are not present.

Comparisons.—Three species of *Pseudophragmina* (*Proporocyclina*) have vertical sections with low, appressed cavities of the

lateral chambers, thick floors and roofs between the cavities, and overlap of the chamber cavities from one tier to the next adjacent one. These are *P.* (*P.*) *advena* (Cushman) from the Cane River formation of the Claiborne group, *P.* (*P.*) *perkinsi* (Vaughan) from the upper Eocene of Jamaica and *P.* (*P.*) *cloptoni* (Vaughan) from the middle Eocene of Lower California. Portions of enlarged vertical sections of these three species are shown as figures 4, 7, 8, 9, plate 100.

The illustrations show clearly the differences between these species and the specimens from Peñon Seep.

LITERATURE CITED

APPLIN, P. L. and APPLIN, E. R., 1944, Regional subsurface stratigraphy and structure of Florida and southern Georgia: Bull. Amer. Assoc. Petrol. Geol., vol. 28, pp. 1673–1753, pls. 1–5, 38 text figs., 1 table.

APPLIN, E. R. and JORDAN, L., 1945, Diagnostic Foraminifera from subsurface formations in Florida: Jour. Paleontology, vol. 19, pp. 129–148, pls. 18–21, 2 text figs.

BARKER, R. W. and GRIMSDALE, T. F., 1936, A contribution to the phylogeny of the orbitoidal Foraminifera, with descriptions of new forms from the Eocene of Mexico: Jour. Paleontology, vol. 10, pp. 231–247, pls. 30–38, 4 text figs.

BERMUDEZ, P. J., 1950, Contribucion al estudio del Cenozoico Cubana: Mem. Soc. Cubana Hist. Nat., vol. 19, pp. 205–375, several tables.

COLE, W. STORRS, 1927, A foraminiferal fauna from the Guayabal formation in Mexico: Bull. Amer. Paleont., vol. 14, no. 51, pp. 1–46, pls. 1–5.

——, 1942, Stratigraphic and paleontologic studies of wells in Florida—No. 2: Florida Geol. Survey Bull. 20, pp. 1–89, pls. 1–16, 4 text figs.

—— and PONTON, G. M., 1934, New species of *Fabularia*, *Asterocyclina* and *Lepidocyclina* from the Florida Eocene: Amer. Midland Nat., vol. 15, pp. 138–147, 2 pls.

——, 1944, Stratigraphic and paleontologic studies of wells in Florida——No. 3, Florida Geol. Survey Bull. 26, pp. 1–168, pls. 1–29, 5 text figs.

—— and BERMUDEZ, P. J., 1944, New foraminiferal genera from the Cuban middle Eocene: Bull. Amer. Paleont., vol. 28, no. 113, pp. 333–350, pls. 27–29.

—— and ——, 1947, Eocene Discocyclinidae and other Foraminifera from Cuba: Bull. Amer. Paleont., vol. 31, no. 125, pp. 191–224, pls. 14–20.

CUSHMAN, J. A., 1919, Fossil Foraminifera from the West Indies: Carnegie Inst. Washington Publ. 291, pp. 21–71, 15 pls., 8 text figs.

——, and BERMUDEZ, P. J., 1937, Further new species of Foraminifera from the Eocene of Cuba: Contrib. Cushman Lab. Foram. Res., vol. 13, pp. 1–28, pls. 1–3.

—— and ——, 1937a, Additional new species of Eocene Foraminifera from Cuba: Contrib. Cushman Lab. Foram. Res., vol. 13, pp. 106–110, pl. 16.

DAVIES, L. M., 1939, An early *Dictyoconus*, and the genus *Orbitolina:* their contemporaneity, structural distinction, and respective natural allies: Trans. Roy. Soc. Edinburgh, vol. 59, pp. 773–790, 2 pls., 6 text figs.

DEPRAT, M. J., 1905, Les dépots Éocènes Neo-Caledoniens; leur analogie avec ceux de la région de la Sonde. Description de deux especes nouvelles d'orbitoïdes: Bull. Soc. Géol. France, vol. 5, 4th ser., pp. 485–516, pls. 16–19, text figs. A–G.

GRAVELL, D. W. and HANNA, M. A., 1938, Subsurface Tertiary zones of correlation through Mississippi, Alabama and Florida: Bull. Amer. Assoc. Petrol. Geol., vol. 22, pp. 984–1013, 7 pls., 5 text figs.

PALMER, DOROTHY K., 1934, Some large fossil Foraminifera from Cuba: Mem. Soc. Cubana Hist. Nat., vol. 8, pp. 235–264, pls. 12–16, 19 text figs.

VAUGHAN, T. W., 1928, Species of large arenaceous and orbitoidal Foraminifera from the Tertiary deposits of Jamaica: Jour. Paleontology, vol. 1, pp. 277–298, pls. 43–50.

——, 1929, Descriptions of new species of Foraminifera of the genus *Discocyclina* from the Eocene of Mexico: Proc. U. S. Nat. Museum, vol. 76, art. 3, pp. 1–18, pls. 1–7.

——, 1945, American Paleocene and Eocene larger Foraminifera: Geol. Soc. America Mem. 9, 175, pp., 46 pls., 11 text figs.

WOODRING, W. P. and DAVIESS, S. N., 1944, Geology and manganese deposits of Guisa-Los Negros area, Oriente Province, Cuba: U. S. Geol. Survey Bull. 935-G, pp. 357–385, pls. 68–77, text figs. 19, 20.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 728–729, 2 TEXT FIGS., SEPTEMBER 1952

HOLOTHUROIDEA FROM THE IOWA DEVONIAN

WARD R. MARTIN
Coe College, Cedar Rapids, Iowa

INTRODUCTION

HOLOTHURIAN plates, including *Protocaudina*, were discovered in acetic acid residues from late Middle Devonian limestones. Previously *Protocaudina* had been reported only from Mississippian and younger rocks (Shimer and Shrock, 1947, p. 227). It therefore is felt this occurrence in the Devonian warrants description.

The author wishes to thank Dr. R. L. Langenheim, Jr., for his helpful suggestions and constructive criticism of the manuscript; and Mr. Ernest Simmons for aid in the preparation of illustrations.

Occurrence.—These fossil holothurians occur in the Cedar Valley formation of the Taghanic stage. The materials were collected at the bottom of the north face of a quarry 2 miles south of Urbana, in the north-east quarter of section 10, T. 85 N., R. 9 W, Benton County, Iowa. Dr. M. A. Stainbrook (personal communication) has identified the horizon as the upper part of the Solon member.

DESCRIPTION OF THE SPECIES

PROTOCAUDINA HEXAGONARIA Martin, n. sp.

Figure 1

Description.—Concavo-convex discs with four central holes and ten outer perforations. The central perforations are circular and the outer holes are semicircular to triangular. The rim is roughly hexagonal. The measurements of the type specimen are as follows:

Diameter of disc	0.336 mm.
Thickness of rim	0.028 mm.
Width of spokes at junction with rim	0.028 mm.
Greatest dimension of central holes	0.056 mm.
Average greatest width of outer holes	0.053 mm.
Average greatest distance between outer and inner holes	0.029 mm.

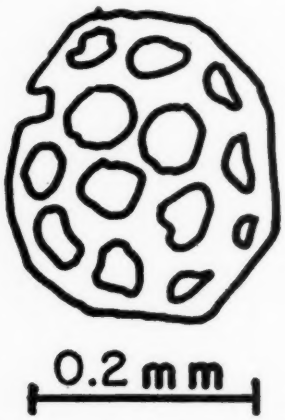


FIG. 1—*Protocaudina hexagonaria* Martin, n. sp. Camera lucida drawing of the holotype.

Remarks.—The observed individuals of this species are very delicate siliceous replacements. Therefore few complete specimens have been obtained, but fragments are abundant. *P. hexagonaria* is distinct from *P. tarquairii* Etheridge and *P. kansasensis* Hanna in possessing a decided hexagonal outline. Also the distance between the outer and inner holes is much less than in *P. tarquairii* and *P. kansasensis*. The absence of ornamentation on the spokes makes it impossible to classify it as *P. hannai* Croneis.

The specific name is derived from the pronounced hexagonal shape.

Collection.—State University of Iowa Repository.

Genus EOCAUDINA Martin n. gen.

Calcareous, fossil holothurian discs with a single central perforation, an intermediate ring of six perforations and an outer ring of approximately eleven perforations. Outline circular to hexagonal. Genotype *Eocaudina septaforaminalis* Martin, n. sp.

EOCAUDINA SEPTAFORAMINALIS Martin, n.sp.

Figure 2

Description.—Calcareous, fossil holothurian discs with a single central perforation, an intermediate ring of six perforations and an outer ring of approximately

eleven performations. The inner perforations are roughly circular and the outer perforations are semicircular to triangular. The outline is hexagonal. Measurements of the holotype are as follows:

Diameter of disc approx. 0.5 mm.
Width of spokes at junction with rim approx. 0.03 mm.
Greatest dimension of central holes 0.088 mm.

Remarks.—Although it seems probable that both *P. hexagonaria* and *E. septaforaminalis* were parts of the same animal, they are classified separately. Croneis (1932, p. 136) comments, ". . . . if these microscopic objects are to have correlative value they must first be classified as so many different bolts, screws, and nuts, regardless of whether they were made in the same factory and out of the same metal!" An artificial classification is employed because it is still impossible to prove whether slightly differing spicules are parts of the same or of separate animals.

Collection.—State University of Iowa Repository.

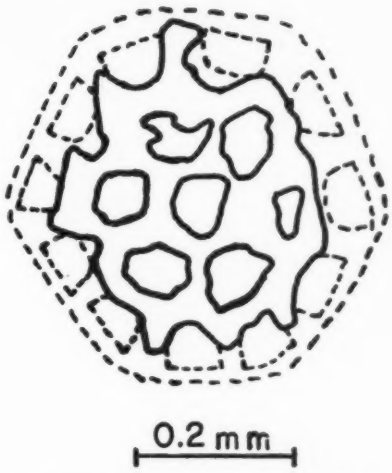


FIG. 2—*Eocaudina septaforaminalis* Martin n. sp. Camera lucida drawing of the holotype. Dotted portion is restored.

REFERENCES

CRONEIS, C., and MCCORMACK, J., 1932, Fossil Holothuroidea: Jour. Paleontology, vol. 6, pp. 137–139.

SHIMER, H. W. and SHROCK, R. R., 1947, Index fossils of North America. pp. i–ix, 1–837, John Wiley, New York.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 730–752, PLS. 104–108, 2 TEXT FIGS., SEPTEMBER 1952

FOSSIL NAUTILOID FAUNAS FROM AUSTRALIA

CURT TEICHERT AND BRIAN F. GLENISTER
University of Melbourne

ABSTRACT—Some Australian nautiloid faunas of Ordovician, Silurian, Devonian, Permian, Jurassic, Cretaceous, and Tertiary age are reviewed with a view of determining their generic composition and affinities. Genera not previously recognised from the Australian region are: *Cryptendoceras, Catoraphiceras, Baltoceras, Protobaltoceras, Bactroceras, Eothinoceras, Arkoceras, Aphetoceras, Pycnoceras, Proterocameroceras, Allopiloceras, Bassleroceras, Rudolfoceras, Meniscoceras?, Cyclendoceras, Nybyoceras, Ormoceras, Beloitoceras,* and *Anaspyroceras* from the Ordovician; *Dawsonoceras, Protokionoceras* and *Geisonocerina* from the Silurian; and *Dolorthoceras, Cayutoceras* and *Sceptrites* from the Devonian. New genera described are *Thylacoceras, Tasmanoceras, Hecatoceras, Madiganella* and *Hardmanoceras* from the Ordovician, and *Buchanoceras, Pectinoceras, Polyelasmoceras, Brachydomoceras, Macrodomoceras* and *Litogyroceras* from the Devonian. The new genus *Plagiostomoceras* has a Middle Silurian genotype but also occurs in the Lower Devonian of Victoria. Type specimens of a number of earlier papers on Ordovician and Silurian nautiloids have been restudied and identifications revised. The ranges of *Cimomia* and *Deltoidonautilus* in Australia differ somewhat from foreign occurrences.

INTRODUCTION

THE purpose of this paper is to make known a number of nautiloid faunas of various ages from the Australian region. In this area the study of nautiloids has long been neglected and only incidental descriptions of casual finds have been recorded. During the past 14 years the senior author has had an opportunity to make substantial collections of nautiloids from the Devonian, Permian, Cretaceous and Tertiary of Western Australia and from the Devonian of Victoria. Numerous other collections from Central Australia, New South Wales and Tasmania have passed through his hands. As may be expected, many of the fossil nautiloid genera represented in Australia are already known from other parts of the world, and the geographical range of these genera is thus considerably extended. To these must be added a number of new genera, mostly from the early and middle Paleozoic.

In view of the impending publication of the Treatise on Invertebrate Paleontology, of which the senior author is chairman of the Section Nautiloidea, it was thought desirable to publish this new information in condensed form so that it may be available for incorporation in the Treatise. Some of the faunas will be described in more detail in future publications. We have included notes on some faunas which we only know from the literature, because they might have escaped the attention of cephalopod workers abroad.

This review of Australian nautiloid faunas is in no way complete. Most of the Paleozoic nautiloids of Queensland and of New South Wales are as yet unknown and any remarks concerning them which may follow are extremely fragmentary.

The material studied by us was supplied by the following institutions: Department of Geology, University of Western Australia, Nedlands, Western Australia; Department of Geology, University of Adelaide; National Museum, Melbourne; Mines Department, Melbourne; Department of Geology, University of Sydney; Australian Museum, Sydney; Queen Victoria Museum, Launceston, Tasmania; Department of Geology, University of Tasmania, Hobart; Tasmanian Museum, Hobart, and Bureau of Mineral Resources, Geology and Geophysics, Canberra. We are greatly indebted to all persons in charge of the paleontological collections in these places for making valuable material available to us, and to Mr. F. S. Colliver who supplied specimens from his private collections.

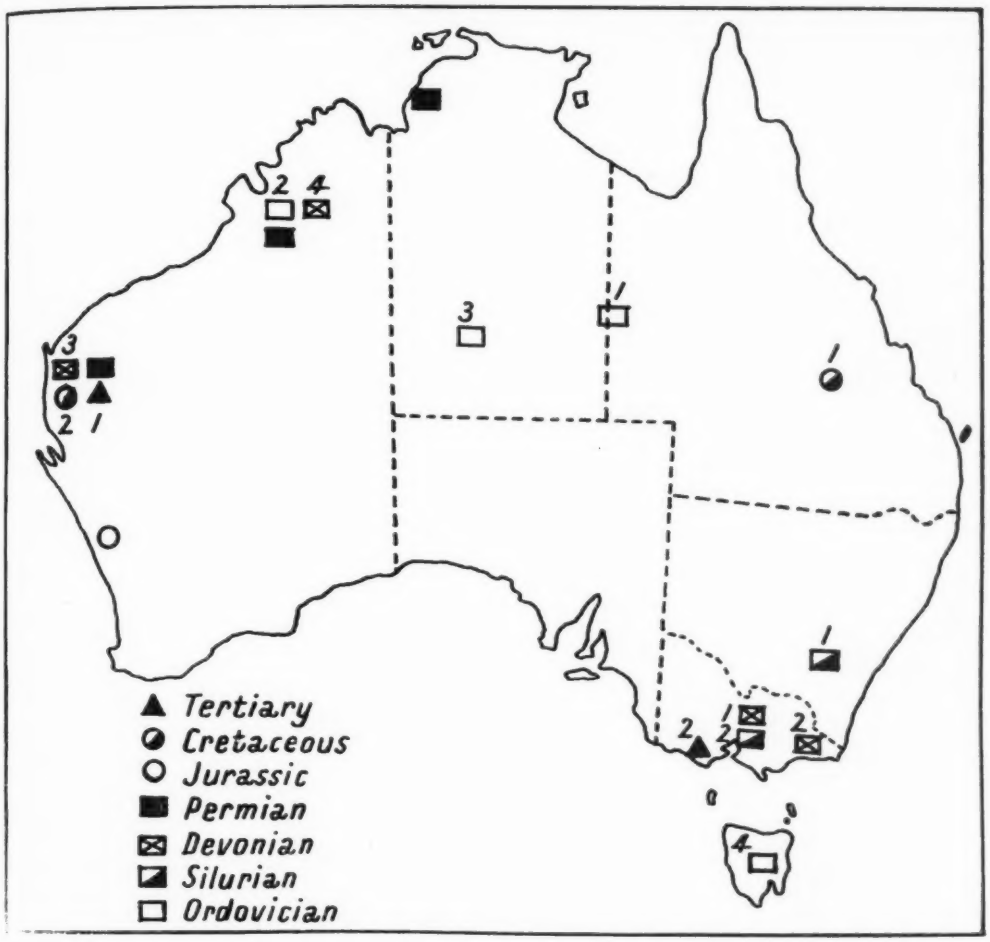


FIG. 1—Location of nautiloid faunas discussed in this paper. Numbers are the same as those used in the text within the respective geological period.

PALEOZOIC FAUNAS

By Curt Teichert and Brian F. Glenister

ORDOVICIAN

Substantial nautiloid faunas of Ordovician age exist in four areas.

1. Western Queensland and Northern Territory.—Very little is known about this fauna which has not yet been described. Whitehouse (1936) reports the presence of large numbers of ellesmeroceratid forms in the Ninmaroo limestone. This seems to be the earliest cephalopod fauna in Australia. In the overlying limestones of the Toko "Series" there occurs an interesting and probably unique fauna of endoceroid and actinoceroid forms. Whitehouse lists *Actinoceras, Deiroceras, Calhounoceras, Endoceras* and *Vaginoceras* as well as "several new genera allied to *Kochoceras, Armenoceras* and other boreal forms."

In the collections of the University of Adelaide there are specimens belonging to *Cryptendoceras, Catoraphiceras* and *Armenoceras* from "low country in front of the Toko Range." This locality is in the Northern Territory, just across the border from Queensland, and is mentioned by Whitehouse.

From these scattered records it would ap-

pear that a wide variety of Ordovician cephalopods is present in this province and that it ranges through a considerable part of that period.

2. Northern part (Kimberley Division) of Western Australia.—The occurrence of Ordovician rocks in the northeastern portion of the Desert Basin was made known by Guppy and Öpik in 1950. Outcrops are restricted to a small area at about 126°E. long. and 18° 40′ S. lat. where 2450 feet of richly fossiliferous limestones and dolomites are present. Nautiloids range through the whole sequence with the exception of the lowermost part, which is reported to be upper Ozarkian in age. The richest concentrations of nautiloids are found in the middle portion of the Emanuel limestone (Guppy and Öpik's Stages II and III).

Perhaps the most interesting aspect of this assemblage is the occurrence of large numbers of orthoconic forms with straight marginal siphuncles which range from short orthochoanitic to full holochoanitic in structure and from eurysiphonate to stenosiphonate in size. Some specimens have endocones, but the majority have not. It has been impossible to classify the material on the presence or absence of endocones. All have connecting rings of varying thickness and most species can be assigned to such genera as *Endoceras*, *Baltoceras*, *Protobaltoceras* and *Bactroceras*. Truly holochoanitic siphuncles appear in the earliest cephalopod-bearing beds, where they are associated with *Eothinoceras* and *Arkoceras* and are, therefore, most probably of middle Canadian age.

Eothinoceras appears in Guppy and Öpik's "Faunal Stage II" of the Emanuel limestone. We have here several specimens of a species which in its measurable features (size of siphuncle, length of camerae) is identical with *Eothinoceras americanum*, with which it also agrees perfectly in the nature of the endosiphuncular structures. The connecting rings are very thick and are V-shaped in longitudinal section, with the apex of the "V pointed inward and approximately median in position" (Ulrich et al., 1944, p. 131). Ulrich et al. describe the American species as "probably breviconic," although their concept is based exclusively on oblique sections. Flower and Kummel (1950, p. 608) suspect that the form may possibly be cyrtoconic. The Australian species is a rather long and narrow, slightly cyrtoconic shell which is sufficiently similar in essential features to the American form to leave little reasonable doubt as to the generic affinities of the two.

Just above the horizon with *Eothinoceras* and *Arkoceras*, at the base of Guppy and Öpik's Stage III, are found *Aphetoceras*, *Cryptendoceras*, *Pycnoceras*, *Bactroceras*, *Endoceras* and a new genus *Thylacoceras* which is related to *Catoraphiceras*.

Still higher in the section follow limestones with *Proterocameroceras* and *Allopiloceras*, and the top of Guppy and Öpik's Stage III is characterized by *Bassleroceras*, *Rudolfoceras*, and *Hardmanoceras* (a new genus of Trocholitidae). *Aphetoceras*, *Proterocameroceras*, *Pycnoceras* and *Thylacoceras* extend up from deeper beds and a number of endoceratids transitional in structure between *Baltoceras* and *Endoceras* are also found.

The basal part of Stage IV contains *Hardmanoceras* and a species akin to *Proto*

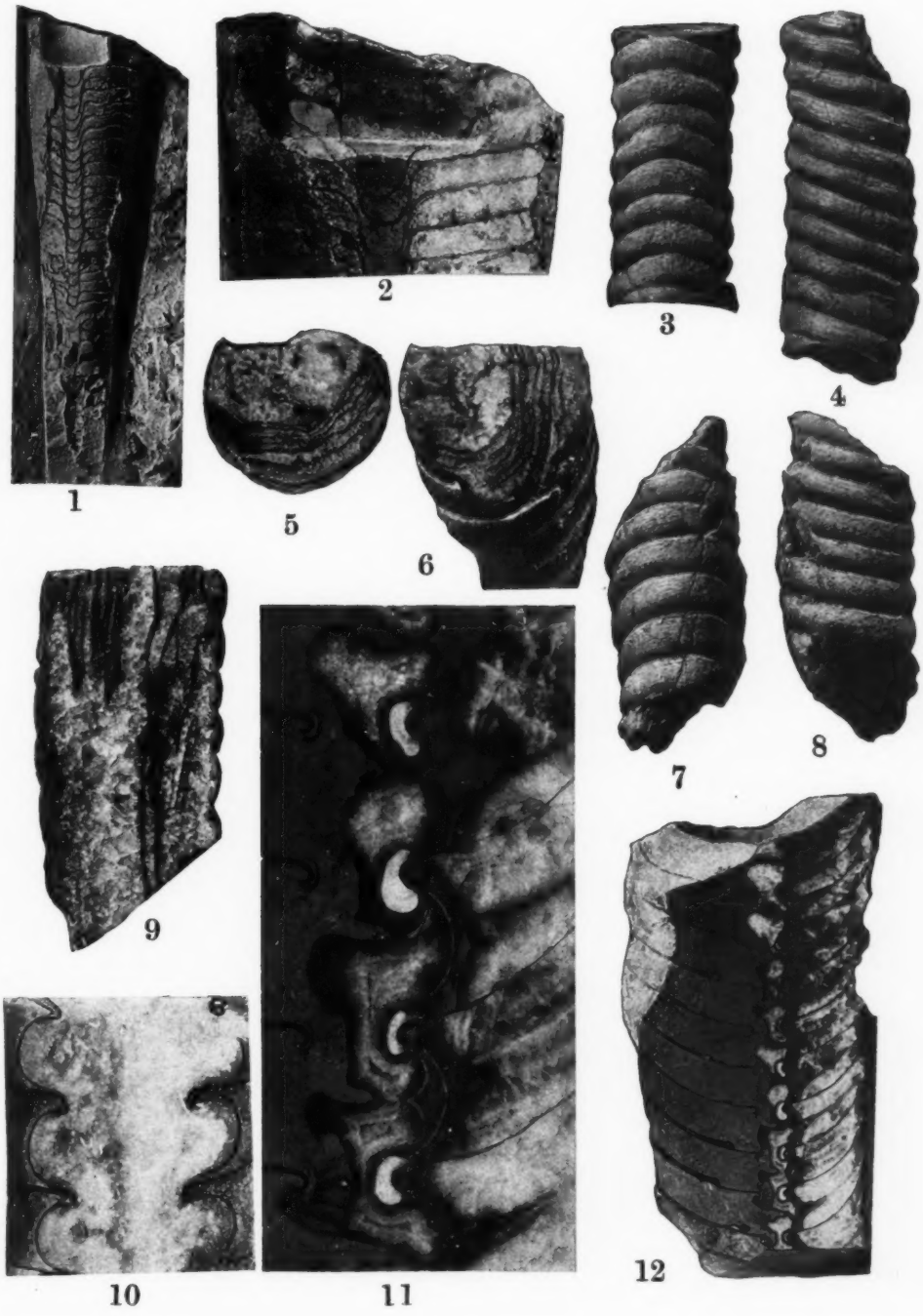
EXPLANATION OF PLATE 104

FIGS. *1–2*—*Thylacoceras kimberleyense* Teichert and Glenister, n. gen., n. sp. Ordovician, Desert Basin, Western Australia. Holotype No. 17,734, *1*, ventral view ×1; *2*, adoral portion of ventral side ×3. (p. 738)

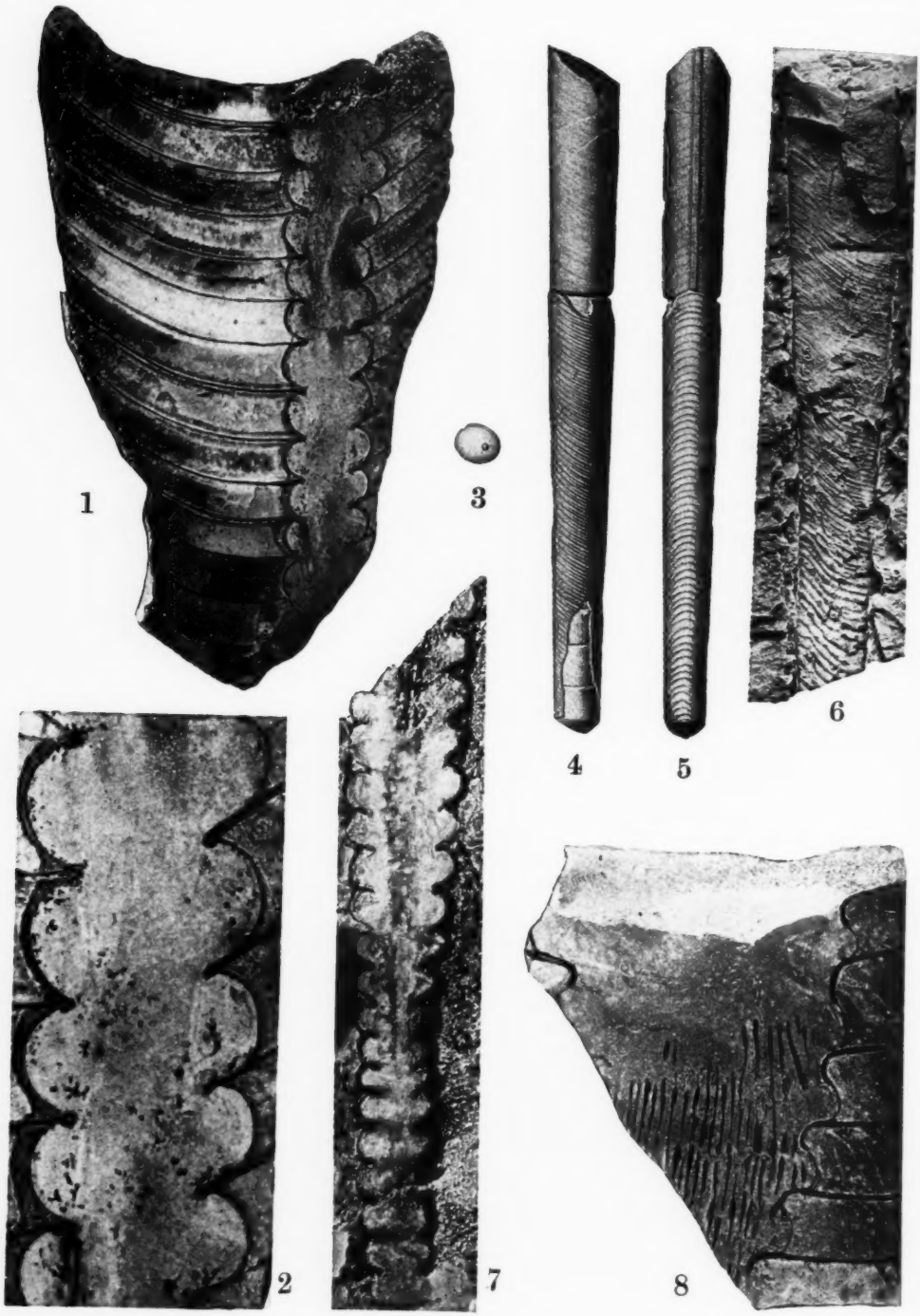
3–9—*Tasmanoceras zeehanense* Teichert and Glenister, n. gen., n. sp. Ordovician, western Tasmania. *3–5*, holotype No. 1986. *3*, concave side ×2; *4*, lateral ×2; *5*, adoral end ×3. *6–9*, paratype No. 1987. *6*, adoral end ×3; *7*, convex side ×2; *8*, lateral ×2; *9*, dorsoventral section ×3. (p. 739)

10—*Hecatoceras longinquum* Teichert and Glenister, n. gen., n. sp. Ordovician, southeastern Tasmania. Holotype No. 20826. Section of siphuncle in dorsoventral mid-plane ×4. See also Plate 105, fig. 7. (p. 740)

11–12—*Buchanoceras graviventrum* Teichert and Glenister, n. gen., n. sp. Devonian, eastern Victoria. Holotype No. 48114/5. *11*, dorsoventral section through siphuncle ×3½; *12*, apical half sectioned in dorsoventral mid-plane ×1. (p. 742)



Teichert and Glenister, Australian nautiloids



Teichert and Glenister, Australian nautiloids

baltoceras Troedsson. The overlying Gap Creek dolomite (Stage V) is poor in species; its lower part has yielded some endoceroids which resemble *Meniscoceras*, a Chazyan genus described by Flower (1941).

Old name	Revised name
Orthoceras Tatei Etheridge (1893)	= *Madiganella tatei* (Etheridge)
?Orthoceras, Etheridge (1894)	= *Madiganella magna* n. sp.?
Actinoceras Tatei Eth. (Tate 1896)	= *Madiganella tatei* (Etheridge)?
Orthoceras gossei Etheridge (1893)	= *Bactroceras gossei* (Etheridge)
Orthoceras microlineatum Tate (1896)	= *Cyclendoceras? microlineatum* (Tate)
Orthoceras larapintense Tate (1896)	= Gen. ind.
Orthoceras ibiciforme Tate (1896)	= Gen. ind.
Orthoceras chewingsi Tate (1896)	= Gen. ind.
Endoceras warburtoni Etheridge (1893, 1894)	= *Catoraphiceras warburtoni* (Eth.)
Endoceras warburtoni Eth. (Tate 1896)	= *Endoceras* n. sp.
Endoceras arenarium Tate (1896)	= *Endoceras arenarium* Tate
Endoceras, Etheridge (1894)	= *Endoceras* sp. ind.
Trochoceras recticostatum Tate (1896)	= Tarphyceratidae, gen. ind.

3. Central Australia.—The presence of Ordovician rocks in Central Australia has long been known, and Ordovician fossils, including cephalopods, have been described by Etheridge (1893, 1894), Tate (1896) and Teichert (1939a). Madigan (1932) named the Ordovician sequence "Larapintine Series" and described it in some detail. He determined its thickness as nearly 6000 feet and obtained fossil collections from horizons approximately 3700–3800 feet above the base of the formation. The occurrence of *Bathmoceras* suggested correlation of these beds with the late Skiddavian or early Llanvirnian of England (Teichert 1939).

We have been able to examine cephalopods from nine different localities in the Macdonnel Range and James Range (approx. 133° E. long and 24° S. lat.), including the types of the species described by Etheridge and Tate. The entire cephalopod fauna consists of about 25 species, some of which are, however, represented by specimens too poor for generic identification.

The previously described species have been revised as follows:

From material collected by the late Dr. C. T. Madigan, mainly from Ellery Creek, we have been able to identify additional species of *Catoraphiceras*, *Endoceras*, *Cyclendoceras* and *Bactroceras*, as well as the following genera: *Baltoceras*, *Cryptendoceras*, *Armenoceras* and *Madiganella*.

Unfortunately, there is insufficient stratigraphical information available to allow of a correlation of faunas from different localities, though it is unlikely that they extend over a great vertical range. On the whole the fauna can be characterized as resembling a typical Baltic *Orthoceras* limestone assemblage as evidenced by the association of large species of *Endoceras* with *Catoraphiceras*, *Baltoceras*, *Bactroceras* and *Bathmoceras*. A slightly younger element is suggested by *Cyclendoceras* and *Armenoceras*, whereas the presence of an unidentifiable genus of the Tarphyceratidae may indicate

---

EXPLANATION OF PLATE 105

FIGS. *1–2*—*Madiganella magna* Teichert and Glenister, n. gen., n. sp. Ordovician, Central Australia. Holotype No. NTO-10. *1*, section in dorsoventral mid-plane ×1; *2*, dorsoventral section of siphuncle ×3. (p. 744)

3–5—*Plagiostomoceras pleurotomum* (Barrande). Silurian of Bohemia. Holotype. *3*, apical ×½; *4*, lateral ×½; *5*, dorsal ×½. (p. 741)

6—*Plagiostomoceras thomasi* Teichert and Glenister, n. gen., n. sp. Devonian, south-central Victoria. Holotype No. 50065 B. Lateral ×1. (p. 741)

7—*Hecatoceras longinquum* Teichert and Glenister, n. gen., n. sp. Ordovician, southeastern Tasmania. Holotype No. 20826. Section in dorsoventral mid-plane ×2. See also Plate 104, fig. *10*. (p. 740)

8—*Polyelasmoceras aduncum* Teichert and Glenister, n. gen., n. sp. Devonian, eastern Victoria. Holotype No. 48267. Section of siphuncle in dorsoventral mid-plane ×3. See also Plate 106, figs. *3*, *4*. (p. 745)

a slightly older fauna somewhere in the area. However, ranges of individual genera in the Australian region may differ slightly from those elsewhere.

We are thus able to confirm earlier conclusions (Teichert 1939a) that the age of that part of the Larapintine series from which most of the cephalopods are derived (3700–3800 feet above its base) is of late Skiddavian to early Llanvirnian age, corresponding to the early Chazyan of North America.

The new genus *Madiganella*, which may belong either to the Westenoceratidae or the Cyrtogomphoceratidae, is unique. Its nearest relatives are genera such as *Faberoceras* and *Cyrtogomphoceras* which are not known from pre-Mohawkian beds. Its appearance in a fauna of Chazyan age would be puzzling. It has no known counterpart in the Baltic province, unless *Stokesoceras balticum* Teichert (1934) of unknown stratigraphic position be regarded as such.

4. Tasmania.—It has only recently been recognized that Ordovician rocks, predominantly limestones, are widely distributed in this island. No coherent account of Ordovician stratigraphy has as yet been given and few fossils have been described. In 1949, Hills and Carey referred all Ordovician, or presumed Ordovician, limestone occurrences to a single formation, the "Gordon River Limestone," but from general discussions by Kobayashi (1940) and Thomas (1948), and from the description of small faunas from scattered localities by Hill and Edwards (1941), Hill (1942), Teichert (1947c), and others, it is obvious that many of the limestone occurrences are of different ages. There are thus several Ordovician limestone formations present and the limestone facies reaches upward into the Silurian.

Cephalopod faunas are scattered, small, and usually not well preserved, because the limestones are hard and massive. The oldest known nautiloids come from Adamsfield where *Piloceras*, *Manchuroceras*, *Utoceras?*, *Endoceras* and *Suecoceras* occur in one limestone layer (Teichert 1947c).

An interesting association has been studied from Railton, in the northern part of Tasmania. This limestone has yielded exceedingly well preserved representatives of two large species of *Nybyoceras* and one large species of *Ormoceras*. These actinoceratids are here associated with a species of *Anaspyroceras*. The vertical range of the last named genus is not yet definitely known and the other two genera range through the Ordovician from the Chazyan upward.

Ordovician limestones at Ida Bay in the southeast and near Zeehan in the western part of the island contain the oldest known discosoroid, described below as *Hecatoceras longinquum*. It is morphologically most similar to *Endostokesoceras* Schindewolf from the Devonian of Germany.

At Zeehan this genus is associated with the new genus *Tasmanoceras*, a peculiarly specialized endoceratid with outwardly convex septal funnels and entirely asymmetric

TABLE 1.—THE DISTRIBUTION OF CEPHALOPOD FAUNAS IN THE AUSTRALIAN REGION

Cincinnatian to Mohawkian	Actinoceratida fauna of Western Queensland	*Hecatoceras-Tasmanoceras* fauna of western Tasmania. *Nybyoceras-Ormoceras* fauna of northern Tasmania (possibly as old as Chazyan)
Chazyan	*Baltoceras*, *Bactroceras*, *Bathmoceras* fauna of Central Australia	Basal Gap Creek dolomite (*Meniscoceras*) of Desert Basin (possibly younger)
Upper Canadian (pre-Llanvirn) to Middle Canadian	*Eothinoceras*, *Basslероceras*, *Proterocameroceras*, *Aphetoceras* etc. of Desert Basin, Western Australia (Emanuel limestone)	Piloceroid fauna of Adamsfield, Tasmania
Basal Ordovician	Ellesmeroceratids of Western Queensland	

endocones. Hill (1943) on the basis of coral evidence puts the Zeehan limestone in the Upper Ordovician. The limestones at Queenstown have yielded a species of *Beloitoceras*. They probably represent a continuation of the limestones found at Zeehan.

SILURIAN

Silurian rocks are widely distributed in Victoria, New South Wales and Queensland, but knowledge of their nautiloid faunas is almost non-existent. The following observations are very fragmentary. The writers have only seen the Silurian faunas of Victoria, which are not particularly rich. The faunas of New South Wales are probably much richer, but only a few small collections have been studied.

1. New South Wales.—In 1904, Etheridge described a species from Bowning as *Cyclolituites bowningensis*. He pointed out that *Cyclolituites* Remelé was an Ordovician genus, but believed nevertheless that the Bowning species should be referred to it. A comparison of the New South Wales species with Remelé's genotype fails to lend support to this view. *Cyclolituites* was established by Remelé in 1886 (p. 467) for *Lituites applanatus* Remelé (1880) which is therefore the genotype by monotypy. This species was not figured until 1889 (Remelé 1889, pl. 1, figs. 6 and 6a). It is a closely coiled, discoidal form, with relatively rapidly expanded whorls and a strongly compressed whorl-section. The body chamber has a slight keel and its anterior portion becomes free from contact with the preceding whorl.

In contrast "*Cyclolituites*" *bowningensis* has slowly expanding whorls with a depressed whorl-section, no trace of a keel, and with the body chamber in contact with the preceding whorl. Restudy of the holotype (Aust. Mus. Sydney, F. 28038) and additional specimens failed to provide a clue to its generic affinities, mainly because it is impossible to establish the position of the siphuncle and the shape of the sutures. As regards mode of coiling and ornamentation it is most similar to *Graftonoceras* Foerste (1925, p. 59) from the Niagaran of North America, but at present its generic status must be held in abeyance. *Cyclolituites* can be removed from the list of Silurian genera.

The collections of the University of Sydney contain specimens of *Actinoceras* (No. 1842) and *Ormoceras* (No. 1841) from the Glenbower beds of the Parish of Cavan. *Ormoceras* is also represented in the Silurian limestones of the Yass district.

2. Victoria.—Silurian rocks occur in great thickness in the central portion of Victoria, including the vicinity of Melbourne. Cephalopods are generally rare. The following species have been described in earlier papers by McCoy (1879) and Chapman (1912, 1914). The original specimens were reexamined by us.

Old name	Revised taxonomic status
Orthoceras (*Cycloceras*) *ibex* (Sow.), (McCoy, 1879, p. 25, pl. 57, figs. 1, 2)	=*Dawsonoceras*? sp. ind.
Orthoceras bullatum (Sow.) (McCoy, 1879, p. 26, pl. 7, figs. 3, 4)	=Gen. et. sp. ind.
Orthoceras capillosum (Bar.) (McCoy, 1879, p. 27, pl. 57, fig. 5)	=Gen. et. sp. ind.
Orthoceras lineare (Münst.), (McCoy, 1879, p. 28, pl. 57, fig. 6)	=Gen. et. sp. ind.
Orthoceras striato-punctatum (Münst.), (McCoy, 1879, pl. 57, figs. 7, 8)	=*Kionoceras* nov. sp.
Cycloceras tenuiannulatum McCoy var. *australis* Chapman, (1912, p. 232, pl. 38, figs. 3, 4)	=*Geisonocerina australis* (Chapman)

An undescribed species of *Dawsonoceras* occurs in the Silurian at Reefton, near Warburton.

In the Melbourne district cephalopods are rare and generally in a poor state of preservation. Annulate orthocones occur but in the absence of internal structure, they cannot be classified with certainty. In addition there are orthoconic forms covered with numerous fine longitudinal lirae; these probably belong to *Protokionoceras*.

DEVONIAN

The Devonian of Australia is rich in nautiloids, few of which have, however, been described. Of outstanding interest is the occurrence of many Pseudorthoceratidae and of many nautiloids with actinosiphonate structure. The following review is very in-

complete. We have seen very few specimens from New South Wales, none from Queensland, and only a preliminary survey has been made of the faunas from Victoria and Western Australia.

1. Lower Devonian of Victoria.—To this period belongs a thick series of sandstones and mudstones, the Yering group, in the country east and north-east of Melbourne. Fossils are preserved as internal and external moulds only. Major limestone lenses occur at Lilydale and Loyola, but cephalopods are very rare in these localities.

From Loyola Chapman (1914, p. 312, pl. 61, figs. 38, 39) described an object as "?*Protophragmoceras* sp.," but after a study of the object itself we are not convinced of its cephalopod, or indeed fossil, nature.

From the Lilydale limestone we have an interesting specimen (No. 1162–3, National Museum, Melbourne), representing a new species which is somewhat intermediate between the genera *Virgoceras* Flower and *Dolorthoceras* Miller as interpreted by Flower (1939, p. 21). The segments of the siphuncle have the same outline as those of the ephebic stage of *Dolorthoceras*, but the septal necks are short and straight as in the Silurian *Virgoceras*. The endosiphuncular deposits are typically those of the Dolorthoceratinae of Flower. The species is best accommodated in *Dolorthoceras*.

The Lower Devonian mudstone and sandstone facies is poor in nautiloid remains. *Buchanoceras*, a new genus of Pseudorthoceratidae, is represented at Kinglake West, 28 miles NE. of Melbourne, by specimens which differ specifically from the genotype which comes from the Middle Devonian of Buchan. These are associated with *Protokionoceras* and indeterminable members of the Oncoceratidae.

2. Middle Devonian of Victoria.—This was a period of widespread transgression in Australia when reef-studded seas were teeming with life. Only a small fraction of the known fauna has so far been described. The only nautiloid faunas which we have been able to study in some detail are those of the Buchan district in eastern Victoria, and of the Northwest Basin in Western Australia.

The outlines of the stratigraphy of the Buchan area have been briefly given by Teichert (1948). The beds are mudstones, limestones and reef limestones, ranging in age from the latest Lower Devonian well up into the Middle Devonian. Nautiloids are not particularly common and are represented mostly by new genera. An outstanding feature is the occurrence of numerous species, whose siphuncles contain actinosiphonate deposits. They belong to several new genera of which *Pectinoceras*, *Polyelasmoceras*, *Brachydomoceras* and *Macrodomoceras* are described below. These are here tentatively referred to the Oncoceratidae, though the highly specialized structure of the endosiphuncular deposits of some of them, e.g. *Pectinoceras*, may ultimately require a change in classification.

This is possibly one of the most concentrated assemblages of actinosiphonate cephalopods known. The actinosiphonate deposits occur in specimens of all sizes and age groups and the material thus offers little support for Flower's view, expressed in 1943, that actinosiphonate deposits form in the gerontic stage only. We have, however, been able to confirm Flower's observation that the actinosiphonate lamellae, if present at all, are always present in the entire siphuncle. They do not exhibit stages of ontogenetic progression. Our material suggests rather strongly that actinosiphonate deposits were formed as an integral part of each siphuncular segment simultaneously with the connecting ring.

The Pseudorthoceratidae are represented by a new genus *Buchanoceras* which as mentioned above appears first in the Lower Devonian. It is related to *Bradfordoceras* and *Cayutoceras*, but has distinct endosiphuncular and cameral deposits. In addition, the genus *Sceptrites* Flower is represented by one specimen.

There are also a number of straight species which are best referred to *Michelinoceras*.

3. Northwest Basin, Western Australia.—Another rich assemblage of actinosiphonate nautiloids is known from the Gneudna limestone of late Middle to early Upper Devonian age, in the Northwest Basin of Western Australia (Teichert 1950). This fauna is quite different in composition from that of the Middle Devonian of Victoria, but it has not yet been studied in detail.

4. Upper Devonian of Desert Basin, Western Australia.—Nautiloids here occur in the richly fossiliferous goniatite beds and reef limestones as described by Teichert (1943, 1949). In 1940 Teichert described the following species from these rocks: *Michelinoceras* cf. *schlotheimi* (Steininger), *Galtoceras kimberleyense* Teich., *Wadeoceras australe* Teich., *Conostichoceras hardmanni* (Etheridge), *Stereoplasmoceras iniquiseptatum* Teich.

The last-named species should be referred to *Cayutoceras*, a genus of Pseudorthoceratidae described by Flower (1939a) from the Upper Devonian of New York. The Australian species, *Cayutoceras iniquiseptatum*, differs in that the second endosiphuncular layer is more strongly developed on the ventral side.

PERMIAN

In the Permian we have two widely distinct faunal provinces, the Western Australian Province and the Eastern Australian Province. The former is of Tethyan affinities, the latter has a more isolated endemic fauna, and the two have little in common (Teichert 1951).

In the Western Australian Province numerous genera occur, including *Pseudorthoceras*, *Mooreoceras*, *Brachycycloceras*, *Domatoceras*, *Stearoceras*, *Titanoceras* and *Phaceras*. In comparison the Eastern Australian Province is very poor in nautiloids. Even the few that do occur have not yet been satisfactorily described. From the Carboniferous and Permian of Queensland Jack and Etheridge (1892) described a few poorly preserved specimens all of which are in need of restudy and revision. From the Permian of New South Wales de Koninck (1877) figured and described some orthoconic forms which he referred to European species, but since de Koninck's types were subsequently destroyed by fire it will not be possible to revise his identifications.

Mesozoic and Tertiary Faunas

By Curt Teichert

JURASSIC

The only Jurassic nautiloid known from Australia is *Nautilus perornatus* Crick (1894), a large form with strong longitudinal striations which occurs in sandstones of Bajocian age near Geraldton in Western Australia. This belongs to the generic group to which Spath (1927) applied the name *Bisiphytes* Montfort. Inasmuch as Spath's choice of *Nautilus striatus* Sowerby as genotype of *Bisiphytes* is invalid, it seems that the nomenclature of this group must be reconsidered.

CRETACEOUS

1. Great Artesian Basin.—*Nautilus* (*Cymatoceras?*) *hendersoni* Etheridge (1901, p. 34) seems to be a typical representative of *Eutrephoceras*. The species was originally recorded from the Lower Cretaceous of the northeast side of the Basin, in central Queensland. Later, Etheridge (1905, p. 16) referred to the same species specimens from the southwestern edge of the Great Artesian Basin in South Australia. These showed fine lirae and striae, both longitudinal and transverse, and Etheridge believed the species to be more closely allied to *Cymatoceras*. This genus, however, has stronger, sinuous, transverse ribs and is probably not represented in the Great Artesian Basin.

2. North-West Basin, Western Australia.—Nautiloids are restricted to the Upper Cretaceous, where they are not particularly common. Undescribed collections made by geologists of the Bureau of Mineral Resources, by E. Craig and by the writer contain *Cymatoceras* and *Cimomia*, represented by a new species each, from beds of Upper Campanian to Lower Maestrichtian age. *Aturoidea* appears slightly higher, in strata of Upper Maestrichtian age, and continues upward into the Eocene.

TERTIARY

1. Western Australia.—The widespread occurrence of *Aturia clarkei* in beds of Miocene age has already been described (Teichert 1944). Pre-Miocene beds are of more restricted distribution and nautiloids are only known from the North-West Basin, where sandstones and sandy limestones of middle to upper Eocene age contain an interesting association of *Aturoidea* with a large species of *Deltoidonautilus* and with a new carinate species of *Hercoglossa*.

The latter is somewhat intermediate between true *Hercoglossa* and *Deltoidonautilus*, but resembles the former in position of siphuncle and shape of sutures.

2. Southeastern Australia.—The oldest nautiloid association is that of *Aturoidea* and *Eutrephoceras* in the Eocene of Western Victoria (Teichert 1943, 1947a). In the Oligocene follow *Deltoidonautilus bakeri* and *Aturia* sp. (Teichert 1947b). The Miocene is characterized by *Aturia australis* and a number of species of *Nautilus*, described by Chapman (1915). These are *Nautilus geelongensis*, *N. altifrons*, *N. felix*, and *N. balcombensis*. The sutures of these four species resemble that of *N. pompilius*, although the lobes and saddles are slightly less strongly developed. *Nautilus balcombensis* differs from typical *Nautilus* in that the surface of its shell, up to a diameter of about one inch, bears a finely reticulate ornamentation of longitudinal and transverse lirae. As already pointed out by Chapman, this is reminiscent of the ornamentation of Mesozoic nautiloids. This feature is insufficient for generic separation.

The age of all four species is given by Chapman as "Janjukian," a stage of the Tertiary which is in part now regarded as Oligocene. However, from the details of the occurrences given by Chapman, it is clear that the beds from which the specimens were obtained are now included in the Balcombian or Batesfordian stages which belong to the Miocene.

TABLE 2.—RANGES OF CRETACEOUS AND TERTIARY NAUTILOID GENERA IN AUSTRALIA

	Lower Cretaceous (Aptian)	Upper Campanian to Lower Maestrichtian	Upper Maestrichtian	Paleocene? to Eocene	Oligocene	Miocene
Eutrephoceras	X			X		
Cymatoceras		X				
Cimomia		X				
Hercoglossa				X		
Deltoidonautilus				X	X	
Aturoidea			X	X		
Aturia					X	X
Nautilus						X

DESCRIPTION OF NEW GENERA

Family ENDOCERATIDAE

Genus THYLACOCERAS Teichert and Glenister, n. gen.

Genotype.—Thylacoceras kimberleyense Teichert and Glenister, n. sp.

Description.—This genus is proposed for forms with smooth conchs which otherwise have the same external aspect as *Catoraphiceras*. The conchs are medium-sized, gently tapering orthocones with a broadly elliptical cross section due to a ventral flattening. The sutures form a deep, apically rounded, narrow ventral lobe, and a shallow, broadly rounded dorsal lobe. The moderately large cylindrical siphuncle is marginal. Septal necks are orthochoanitic, reaching two thirds of the distance towards the preceding septum. Connecting rings reach from the tip of one septal neck to the tip of the next preceding septal neck and are considerably thickened in the vicinity of the septal foramina.

Affinities.—Considerable difficulties are encountered in determining the taxonomic position of *Thylacoceras* because of the unsatisfactory nature of a classification based largely on the presence of endocones and annulations of the conch. The septal necks of *Catoraphiceras* are not well known, but it would seem that *Thylacoceras* is closely related to this genus, from which it differs in the absence of annulations.

The name is derived from Greek θυλακος, pocket, with reference to the deep pocket-like ventral lobe.

THYLACOCERAS KIMBERLEYENSE Teichert and Glenister, n. sp.

Plate 104, figures 1–2

Description of holotype (No. 17,734 Bureau of Mineral Resources, Geology and Geophysics, Canberra).—The holotype is an orthoconic phragmocone which is 48 mm. long. The lateral diameter is greater than the dorsoventral diameter due to a flattening of the conch across the venter. At its anterior extremity the conch measures 17.2 mm. in the lateral plane and 15.2 mm. in the

dorsoventral plane, while at the posterior extremity the lateral diameter is 9.3 mm. The siphuncle is almost in contact with the ventral wall of the conch. Its diameter is 4.2 mm. at the anterior end, and the segments are cylindrical. The shell is smooth, except for the presence of fine transverse growth lines.

The suture forms a deep adapically rounded lobe on the venter. At the anterior end of the specimen this lobe is 3.6 mm. deep and 2.6 mm. wide. Eight camerae occupy a distance equal to the lateral diameter. The septal necks are orthochoanitic, reaching two-thirds of the distance towards the preceding septum. To the tip of each septal neck is attached a thick connecting ring which reaches adapically to the tip of the preceding septal neck. These connecting rings are twice as thick as the septum at the septal foramina, but decrease in thickness rapidly both adorally and adapically until they have about the same thickness as the septum.

Occurrence.—Throughout Stage III of Emanuel limestone, Emanuel Creek, Desert Basin, Western Australia. (See Guppy and Öpik, 1950, for details of locality and of stratigraphical divisions).

Genus TASMANOCERAS Teichert and Glenister, n. gen.

Genotype.—Tasmanoceras zeehanense Teichert and Glenister, n. sp.

Description.—Small endoceroids with slowly expanding, straight or weakly curved siphuncles. Siphuncle segments slightly expanded between septa, sloping at a moderately high angle to axis of siphuncle. Structure of septal necks unknown but probably holochoanitic. Siphuncle with strongly asymmetric endocones which tend to develop in greater numbers on one side (probably the ventral) of the siphuncle than the other.

Affinities.—No precisely similar forms are known among the Endoceratidae. Schindewolf (1942) described asymmetrical deposits in *Baltoceras*, but Flower (1947) believed these to be of inorganic origin, having failed to detect any traces of endocones in them. Apparently this genus requires further investigation.

TASMANOCERAS ZEEHANENSE Teichert and Glenister, n. sp.
Plate 104, figures 3–9

Description of holotype (No. 1986, Department of Geology, University of Melbourne).—The holotype is a portion of a siphuncle consisting of ten segments and measuring 21.3 mm. in length. At the anterior end of the specimen the dorsoventral diameter is 8.6 mm. and the lateral diameter 8.7 mm., while the corresponding measurements at the posterior end are 8.4 mm. and 8.5 mm. The specimen is gently curved. On the concave side the septa probably sloped towards the siphuncle at an acute angle, but on the convex surface the angle was almost 90°. This, together with the fact that the siphuncular segments slope backwards from the concave towards the convex surface at an angle of 67° to the axis of the siphuncle, suggests that the siphuncle was situated close to the concave surface of the conch. Siphuncular segments are gently convex; four of them occupy a distance equal to the dorsoventral diameter.

Both the anterior and the posterior end of the specimen have been polished and show closely packed endocones. These endocones are not truly conical in shape, but are in the form of irregularly annulated half cones most of which reach the periphery of the siphuncle along the flanks. Considerable recrystallisation has occurred, but it appears that the endocones were more numerous from about the centre of the siphuncle to its concave side, few endocones being visible in the partially damaged convex half of the specimen. Weathering has produced furrows between the endocones, along the flanks of the siphuncle where they reach the periphery, leaving them standing as longitudinal ridges.

Description of paratype (No. 1987, Department of Geology, University of Melbourne).—The paratype is a portion of a siphuncle, 17.8 mm. long, which has been sectioned in the dorsoventral mid-plane. The dorsoventral diameter is 9.0 mm. at the anterior end and 8.3 mm. at the posterior end of the specimen. It is slightly curved and consists of seven flatly convex siphuncular segments.

At the anterior end of the specimen many

excentrically situated endocones occur in the convex half of the siphuncle, a much smaller number being present in the concave half. Weathering has produced longitudinal ridges where these endocones meet the periphery of the siphuncle at the flanks. The last formed endocone has left a conical chamber which was apparently free from organic structures; 6 mm. adapically from the anterior end of the specimen this cone opens into an endosiphuncular tube which is rather irregular in shape but averages 0.4 mm. in diameter and is situated 4 mm. from the concave surface of the siphuncle. Four diaphragms cross this endosiphuncular tube.

Occurrence.—Ordovician limestone in Smelter's Road Quarry near Zeehan, Western Tasmania.

Family Discosoridae
Genus Hecatoceras Teichert and Glenister, n. gen.

Genotype.—*Hecatoceras longinquum* Teichert and Glenister, n. sp.

Description.—Conch unknown, but probably gently curved with the siphuncle close to the concave side. Siphuncle narrow, gently expanding. Siphuncular segments slope backwards from the concave towards the convex side at a low angle.

Septal necks short, cyrtochoanitic with moderately long brims. Connecting rings thin and highly inflated; evenly rounded on convex side, where adnation area is small, but on concave side most strongly inflated immediately behind the septal neck, and with a large adnation area. Three types of deposit in siphuncle: (1) A continuous laminated layer lining the connecting rings and septal necks, thinnest at septal neck. (2) Endocones, leaving central endosiphuncular canal. (3) Massive organic deposit between the endocones and the endosiphuncular lining. The latter forms inside the endosiphuncular lining in the vicinity of the septal necks and grows in the manner of pendant deposits until only a narrow space remains between deposits from adjacent septal necks.

Affinities.—*Hecatoceras* lies close to *Endodiscosorus* (*Endostokesoceras*) Schindewolf. *Hecatoceras* lacks the ventral flattening of the connecting rings and is less rapidly expanding and less strongly curved. The septa of *Hecatoceras* form a more narrowly acute angle with the axis of the siphuncle on the concave side, and the adnation surface is much wider. Septal necks are shorter.

The name is derived from Greek ἕκατος, far off.

Hecatoceras longinquum Teichert and Glenister, n. sp.

Plate 104, figure 10; plate 105, figure 7

Description of holotype (No. 20826, Department of Geology, University of Tasmania).—The holotype is a well-preserved siphuncle 50.7 mm. long, consisting of 19 segments. It is roughly circular in cross section, having a dorsoventral diameter of 4.0 mm. at the posterior end and 7.8 mm. at the anterior end. The siphuncle is slightly curved. The septa form a much more acute angle with the axis of the siphuncle on the concave than on the convex side, indicating that the siphuncle was probably situated close to the concave side of the conch. The segments of the siphuncle slope backwards from the concave towards the convex side at an angle of about 84° with the axis of the siphuncle. From two to two and a half siphuncular segments occupy a distance equal to the dorsoventral diameter.

The specimen has been sectioned in the dorsoventral mid-plane. The septal necks are short and cyrtochoanitic, being bent through 180°. The segments are highly inflated; they are symmetrical on the convex side, but on the concave side attain their maximum width just behind the septal neck and taper apically to the preceding septal neck. In a typical segment where the diameter at the septal foramen is 3.1 mm. and the length of the segment 2.4 mm., the

---

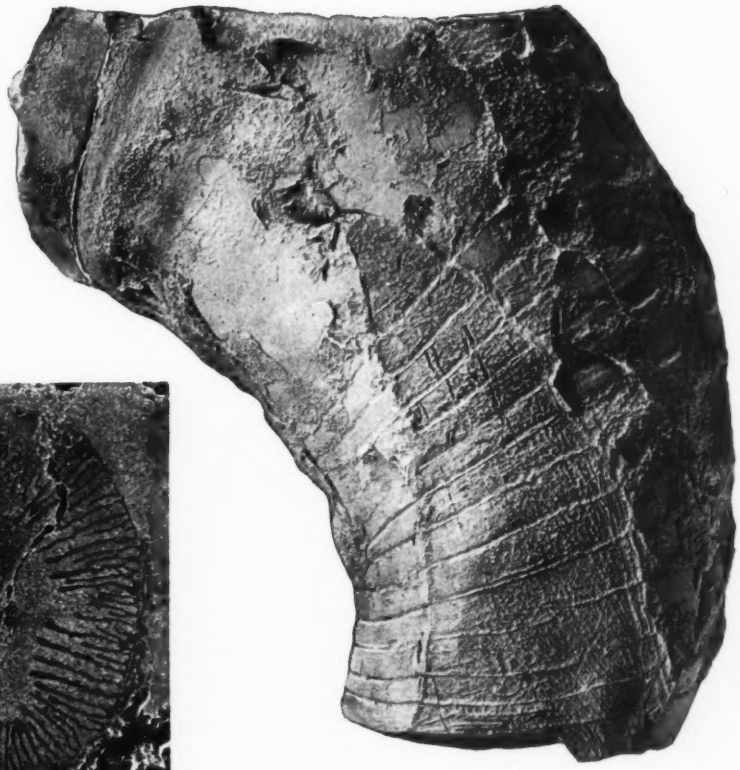
Explanation of Plate 106

Figs. *1–2*—*Macrodomoceras howitti* Teichert and Glenister, n. gen., n. sp. Devonian, eastern Victoria. Holotype No. 47903. *1*, lateral ×1; *2*, ventral ×1. See also Plate 107, figs. *4–5*. (p. 747)

3–4—*Polyelasmoceras aduncum* Teichert and Glenister, n. gen., n. sp. Devonian, eastern Victoria. Holotype No. 47903. *3*, transverse section of siphuncle ×4; *4*, lateral ×1. See also Plate 105, fig. *8*. (p. 745)

1

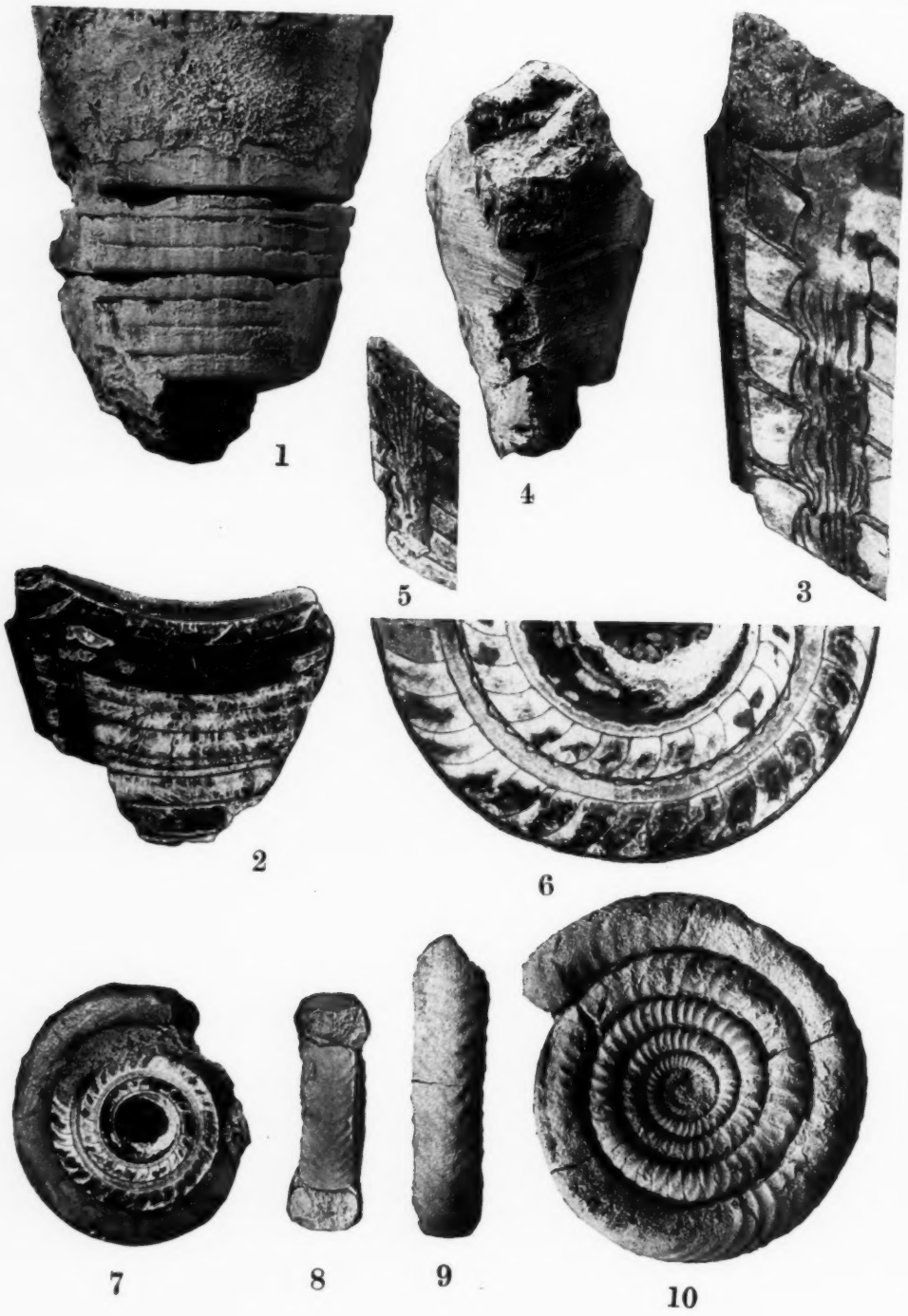
2



3

4

Teichert and Glenister, Australian nautiloids



Teichert and Glenister, Australian nautiloids

septal necks have a length of 0.3 mm., the brims a length of 0.4 mm., and the maximum diameter of the segment is 5.4 mm. The area of adnation is 1.4 mm. wide on the concave side, and 0.6 mm. on the convex side.

The deposits of the siphuncle appear to be of three types. On the outside a thin, apparently continuous, laminated deposit lies directly in contact with the connecting rings and septal necks. This deposit is the endosiphuncular lining. It tends to be thinnest around the septal necks. On its inner side follows a dense structureless calcareous deposit. This forms over the endosiphuncular lining in the vicinity of the septal necks, having a shape similar to that of the pendant deposits found in some Pseudorthoceratidae. Only a thin space remains between deposits formed around successive septal necks. In the center of the posterior half of the siphuncle lies a narrow endosiphuncular canal. It is continuous adorally with a conical mass of crystalline calcite which probably represents recrystallised endocones. This material is similar to that filling the endosiphuncular canal.

Occurrence.—Ordovician limestone, Mystery Creek Quarry, Ida Bay, southeastern Tasmania.

Family MICHELINOCERATIDAE
Genus PLAGIOSTOMOCERAS Teichert and Glenister, n. gen.

Genotype.—*Orthoceras pleurotomum* Barrande, 1874, p. 412; 1866, pl. 224, figures 12–13; 1868, pl. 296, figures 1–24; 1870, pl. 366, figures 1–4. (See pl. 105, figs. 3–5 of this paper).

Description.—Slender, long orthoconic shells with circular to very slightly compressed cross section. Sutures straight or slightly oblique, may develop faint lateral lobes. Septa moderately concave. Aperture strongly oblique, sloping adapically from the antisiphuncular to the siphuncular side. In side view outline of aperture appears somewhat sinuous, sloping more strongly on the lateral sides and flattening both near the antisiphuncular and the siphuncular sides. Surface of the shell covered with growth lines and weak ridges which are parallel to the aperture.

Siphuncle stenosiphonate, subcentral. Septal necks orthochoanitic.

The generic name is derived from Greek πλάγιος, oblique; στόμα, mouth.

Occurrence.—The genotype ranges from the Upper Ordovician to the Middle Silurian (Étages Dd5 to Ee2 of Barrande), and is known from numerous localities in Bohemia. More than 20 other species described by Barrande, mostly of Silurian age, can be placed in this genus.

The genus is represented in the Lower Devonian of Victoria by the species described under the name of *Plagiostomoceras thomasi.*

PLAGIOSTOMOCERAS THOMASI Teichert and Glenister, n. sp.
Plate 105, figure 6

The only specimens now available are two external moulds. An internal cast which was seen some years ago has since disappeared.

Description of holotype (No. 50065B, Mines Department of Victoria, Melbourne).—The holotype is an external mould of portion of a shell 89 mm. long, expanding from 13.5 mm. at its adapical end to 15.5 mm. at its adoral end. A small portion of the internal cast of the living chamber which adheres to the adoral end of the specimen is quite flatly compressed so that shape of the cross section of the conch cannot be stated. From the course of the growth lines (see be-

---

EXPLANATION OF PLATE 107

FIGS. *1–3*—*Brachydomoceras erectum* Teichert and Glenister, n. gen., n. sp. Devonian, eastern Victoria. Holotype No. 48171. *1*, lateral ×1; *2*, section in dorsoventral mid-plane ×1; *3*, dorsoventral section of siphuncle ×3. (p. 746)

4–5—*Macrodomoceras howitti* Teichert and Glenister, n. gen., n. sp. Devonian, eastern Victoria. *4*, ventral view of a specimen showing hyponomic sinus ×1; *5*, dorsoventral section through siphuncle of above specimen ×3. (p. 747)

6–10—*Hardmanoceras lobatum* Teichert and Glenister, n. gen., n. sp. Ordovician, Desert Basin, Western Australia. *6–7*, paratype No. 17,736. *6*, median section of outer whorls ×3; *7*, median section ×1. *8–10*, holotype No. 17,735. *8*, ventral of phragmocone ×1; *9*, ventral of living chamber ×1; *10*, lateral ×1. (p. 748)

low) it appears that the shell was lying on one of the lateral sides. The figures stated above correspond, therefore, to the dorso-ventral diameters. The cross section of the conch was probably somewhat compressed.

The outside of the shell was covered with growth lines which are very fine in the adoral region of the specimen for a distance of about 55 mm. from its adoral end. They have a strongly oblique slope across the flanks, flattening out as they approach both the ventral and the dorsal side of the shell. This course of the growth lines suggests a strongly oblique apertural margin with a deep and broad hyponomic sinus. In the adoral portion of the shell the growth lines are about 0.5 mm. apart. Adapically they become stronger, and at the adapical end of the specimen the surface is covered with fine ribs, about 1 mm. apart, which have the same course as the growth lines in the adoral part.

Siphuncle and sutures are unknown.

Description of paratype (No. 50065F, Mines Department of Victoria). The paratype is an external cast with very similar features to the holotype. The gradual increase in prominence of the oblique growth lines from the adoral to the adapical end of the shell is very obvious.

Occurrence.—In basal Lower Devonian (Yeringian) mudstones near Mt. Matlock, Victoria.

Remarks.—This species resembles the Bohemian genotype in its external features, except that in its adapical portion the growth lines become much more strongly expressed and develop into weak ribs.

The species is named in honour of Dr. D. E. Thomas.

Family PSEUDORTHOCERATIDAE
Genus BUCHANOCERAS Teichert and Glenister, n. gen.

Genotype.—*Buchanoceras graviventrum* Teichert and Glenister, n. sp.

Description.—Moderately large to large, gently tapering orthoconic shells with circular to slightly depressed cross section. Sutures straight and transverse, septa moderately deep. Siphuncle slightly off centre, with a diameter equal to about one-tenth that of the conch. Cameral deposits occur in ventral and ventrolateral parts of the camerae, where epi- and hyposeptal deposits are in contact, forming a "pseudoseptum." Deposits diminish rapidly in thickness towards dorsolateral sides; dorsal part of camerae either without deposits or with thin episeptal deposits only.

Septal necks cyrtochoanitic; brim recurved so as to be parallel to the septum. Length of septal neck generally slightly more than that of brim on dorsal side, and may be more than twice length of brim on the ventral side, where the necks are longer than on the dorsal side. Connecting rings convex outwardly, diameter of siphuncular segments less than their length. Siphuncular deposits of pendant type, generally consisting of an inner laminated cingulus[1] formed around the septal neck, surrounded by a more massive recrystallised deposit which extends mainly adorally and fills the ventral part of the siphuncle. Dorsal part of siphuncle either without deposits or with weakly developed deposits.

Affinities.—*Buchanoceras* is closely related to *Cayutoceras* Flower and possibly to *Bradfordoceras* Flower and Caster. The most distinctive features which link *Buchanoceras* to the Cayutoceratinae are the composite nature of the siphuncular deposits and the concentration of both cameral and siphuncular deposits on the ventral side.

In addition to the genotype from the Middle Devonian of Buchan, *Buchanoceras* is represented by two species in sandstones of the Lower Devonian Yering group of Kinglake West, Victoria.

BUCHANOCERAS GRAVIVENTRUM Teichert and Glenister, n. sp.
Plate 104, figures 11–12

Description of holotype (No. 48114/5 Mines Department, Melbourne, Victoria)—The holotype is a gently tapering orthocone, 114 mm. long. Its surface is badly weathered, so that the shapes of the cross section and of the sutures are not well

[1] This term was suggested by Dr. L. Bairstow (personal communication) to replace the term annulus of Flower (1946). Annulus has long been used for the zone near the base of the body chamber of *Nautilus* where the mantle is attached to the shell.

known. The conch is broken at its mid-length and the apical half sectioned in the dorsoventral plane. The dorsoventral diameters at the posterior and anterior ends are 30 mm. and 37.5 mm. respectively and the conch seems to be approximately circular in cross section.

The sutures are probably straight and transverse. Five and a half camerae occupy a distance equal to the dorsoventral diameter. The septa are uniformly concave and one and a half camerae deep. The siphuncle is subcentral throughout the conch. At the posterior end of the specimen the septal foramen has a diameter of 3.1 mm. and is situated 10.5 mm. from the venter and 16.4 mm. from the dorsum.

Cameral deposits are present in all camerae of the sectioned half of the holotype. They almost fill the camerae on the ventral side of the siphuncle, but are very thin on the dorsal side. In the posterior part of the phragmocone in the ventral portion of the camerae these deposits leave only a thin pseudoseptum. In the dorsal portion of the camerae only episeptal deposits are known. They are extremely thin and extend only two-thirds of the distance from the wall towards the siphuncle.

In a typical segment, the siphuncle is inflated from 3.30 mm. at the septal foramen to 5.50 mm. at its greatest diameter, half way between successive foramina. The connecting rings are uniformly convex. The septa are thickened towards the septal necks. The septal necks are recurved so that the distal extremity of the brim is almost parallel to the septum. The neck is considerably larger than the brim, especially on the ventral side, where its length may exceed twice that of the brim. In a typical siphuncle segment where the height of the camera is 5.30 mm. and the diameter of the septal foramen 3.45 mm., the septal neck on the dorsal side has a length of 0.75 mm. and bears a brim of length 0.55 mm., while on the ventral side the length of the septal neck is 0.95 mm., and that of the brim 0.40 mm. The area of adnation generally equals the length of the brim. Siphuncular deposits originating from the septal necks on the ventral side practically fill the siphuncle, while only very thin cinguli occur on the dorsal side. The siphuncular deposits consist of two distinct components. On the inside occur thin laminated cinguli. They are attached only at the septal neck and do not extend along the connecting ring. Surrounding them are recrystallised deposits of typically pendant type. In one case only do two adjacent pendant deposits come into contact; in all others they are separated from each other and from the connecting ring by a thin layer of matrix. The recrystallised deposits are irregular in shape, but generally have a pronounced dorsal projection on their anterior border which almost reaches the dorsal side of the connecting ring at about the midheight of the camerae. The cinguli of the dorsal side also consist of these two distinct layers, both of approximately equal thickness, but they together rarely attain one-quarter the thickness of even the laminated cinguli of the ventral side.

Occurrence.—Holotype comes from 600 feet above top of Cave limestone, 660 yards north of bridge over Buchan River, Buchan, eastern Victoria, where it is associated with *Gyroceratites desideratus* and *Lobobactrites inopinatus* (Loc. B, Teichert 1948, p. 61). The species also occurs at about the same stratigraphical level elsewhere in the Buchan group.

Family CYRTOGOMPHOCERATIDAE
Genus MADIGANELLA Teichert and Glenister, n. gen.

Genotype.—*Madiganella magna* Teichert and Glenister, n. sp.

Description.—Large, straight longicones with moderately concave septa and sinuous transverse sutures with a broad ventral lobe. Outside of shell probably smooth. Siphuncle strongly nummuloidal, diameter of segments equalling one-fourth to one-fifth that of the conch. Position of siphuncle varies between just off-centre and halfway between the centre and the shell wall. Septal necks are very short and cyrtochoanitic; connecting rings become strongly thickened with age and in the mature stage have a wide surface attachment with both the anterior and the posterior surface of the septa surrounding the septal foramina. Cylindrical tube present in siphuncle.

Affinities.—This genus is closely similar to *Faberoceras* Flower and to *Cyrtogomphoceras* Foerste. Both genera have been well discussed by Flower (1946) and *Madiganella* differs from both in being straight. *Faberoceras* is exogastric, *Cyrtogomphoceras* endogastric and *Madiganella* is, therefore, perfectly intermediate. *Landeroceras* which Flower calls "a straight edition of *Cyrtogomphoceras*" is more breviconic and has a marginal siphuncle. *Strandoceras* Flower, whose siphuncle structure resembles that of *Madiganella* (see Teichert, 1930, p. 300), is an endogastric compressed form with large body chamber.

The endosiphuncular tube resembles that of *Harrisoceras* described by Flower (1949b). In other respects *Madiganella* and *Harrisoceras* are however quite dissimilar. It thus seems to us that the endosiphuncular tube does not posesss the taxonomic significance attributed to it by Flower and that it may be a feature which has developed independently in different families.

The siphuncle structure of *Landeroceras* is not well known, but that of the other four genera is so similar that they should be grouped in one family, the Cyrtogomphoceratidae of Flower (1940). In 1946, Flower united *Faberoceras* with the Westenoceratidae,[2] but it seems best to retain in this family primarily smaller and more breviconic genera, one or more of which may have given rise to the larger Cyrtogomphoceratidae.

The genus is named after the late Dr. C. T. Madigan, geologist and explorer of Central Australia.

Occurrence.—*Madiganella* is probably represented by three species from five different localities in the Ordovician belt of Central Australia. In addition to the genotype, *Orthoceras tatei* Etheridge as well as at least one other species must be placed in this genus.

[2] The genus *Westenoceras* was established by Foerste in 1924. Foerste and Teichert (1930) stated that it had been intended to name this genus after T. C. Weston, but since this is not apparent from the original publication a change in spelling to *Westonoceras* as proposed by Foerste and Teichert is not admissible under the International Rules of Zoological Nomenclature and the original spelling should be retained.

MADIGANELLA MAGNA Teichert and Glenister, n. sp.
Plate 105, figures 1–2

Description of holotype (No. NTO-10 Department of Geology, University of Adelaide).—The holotype is part of a straight longiconic phragmocone. It is 91 mm. long with a dorsoventral diameter of 56 mm. and a lateral diameter of 51 mm. at the adoral end. The shell wall has been removed from the conch and a portion of the camerae weathered so that it is impossible to determine the shell configuration or the exact rate of apical tapering. It however seems probable that the conch tapered gently adapically. The suture is sinuous and transverse. A broad and prominent lobe occurs on the venter followed by a gently rounded saddle on the ventrolateral flank, a shallow lobe across the dorsolateral flank, and a more narrowly rounded saddle across the dorsum.

The siphuncle is strongly nummuloidal. Where the dorsoventral diameter is 56 mm. the ventral surface of the siphuncle is situated 9 mm. from the venter. The siphuncle has a diameter equal to one-sixth that of the dorsoventral diameter. Septal necks are cyrtochoanitic and very short, the brim being sharply recurved into a position parallel to the adapical surface of the septum. To the tip of the brim is attached a connecting ring of about the same thickness as the septum. On the outside of this a second layer of the connecting ring is formed. In the chambers at the adoral end of the specimen this outer layer is quite thin but it becomes thicker with age, so that at the adapical end it is about six times the thickness of the septa. This outer layer is attached to the septa near the septal neck and is continuous with thin episeptal and hyposeptal layers which extend along the free part of the septa almost to the wall of the conch. Traces of an endosiphuncular tube close to the dorsal side of the siphuncle are preserved.

Occurrence.—The holotype is from Ellery Creek, in the Heavitree Range, about 50 miles west of Alice Springs, Central Australia. Representatives of this and related species are known from a number of additional localities in the Ordovician belt west of Alice Springs.

Family ONCOCERATIDAE

In the Middle Devonian of eastern Victoria there occur a number of quite distinct forms of more or less straight to cyrtoconic brevicones which are endogastric, have uncontracted apertures, and siphuncles with strongly developed actinosiphonate deposits. This group of new genera, some of which are here described as *Pectinoceras*, *Polyelasmoceras*, *Brachydomoceras*, and *Macrodomoceras*, is not closely comparable to any known family group from the Northern Hemisphere. We are tentatively including them in the Oncoceratidae to indicate their general relationships, but more detailed study will probably show that they belong to a distinct family.

Genus PECTINOCERAS Teichert and Glenister, n. gen.

Genotype.—Phragmoceras subtrigonum (McCoy).

Description.—Rapidly expanding endogastric cyrtoconic shells with unconstricted aperture and slightly compressed to oval cross section, the ventral outline being more narrowly rounded than the dorsal. Sutures straight except for a low broad saddle across the venter. Septa moderately concave. Septal necks orthochoanitic.

Siphuncle close to, but not in contact with ventral (concave) side of conch. Siphuncular segments gently and equally inflated on all sides, maximum diameter equal to one-sixth that of conch. Endosiphuncular deposits actinosiphonate, consisting of irregularly alternating long and short lamellae which are continuous throughout many segments. Larger lamellae sometimes reach centre of siphuncle. All lamellae, except the shortest, develop lateral projections so that in cross section the longer lamellae appear bipectinate. The lateral projections may themselves branch.

The name refers to the pectinate structure of the endosiphuncular lamellae.

Affinities.—Pectinoceras probably is closely related to the Silurian *Danaoceras*, but its siphuncle is almost three times the size of that of the latter. The siphuncular structures of *Danaoceras* are imperfectly known, making closer comparisons impossible.

PECTINOCERAS SUBTRIGONUM (McCoy)

1876 *Phragmoceras subtrigonum*, F. McCOY, Prod. Pal. Vict., Dec. 1V, pl. 35, figs. 6, 6a.
1940 *Danaoceras subtrigonum* (McCoy), C. TEICHERT, Roy. Soc. West. Aust., Jour., vol. 26, pp. 64–65, pl. 3, figs. 7–9, pl. 4, fig. 11.

A detailed description of the holotype was given by Teichert (1940).

Occurrence.—Fairly common in calcareous nodules in the lowermost 300 feet of the Taravale formation, Buchan group, and occurs in many localities north and east of Buchan, East Gippsland, Victoria.

POLYELASMOCERAS Teichert and Glenister, n. gen.

Genotype.—Polyelasmoceras aduncum Teichert and Glenister, n. sp.

Description.—Rapidly expanding strongly curved cyrtocones with large siphuncle close to concave side. Cross section subcircular but slightly depressed and with a marked flattening across the concave side. Living chamber long, aperture straight, shell smooth.

Septa moderately concave, sutures straight, camerae shallow. Septal necks long and cyrtochoanitic with short brims. Connecting rings thin, moderately inflated, and area of adnation large. Actinosiphonate lamellae of a straight, uniform, and generally unbranched type. At maturity individual lamellae are continuous through many siphuncular segments.

The name of the genus is derived from Greek πολύς, many, and ἔλασμα, lamella, with reference to the large number of lamellae in the siphuncle.

POLYELASMOCERAS ADUNCUM Teichert and Glenister, n. sp.

Plate 105, figure 8; plate 106, figures 3–4

Description of holotype (No. 48267, Mines Department, Melbourne).—The holotype is a rapidly expanding cyrtocone, strongly curved, with the siphuncle on the concave side. It has a length of 125 mm., 51 mm. of which consists of body chamber. Much of the aperture has been preserved, and it appears to be straight. The cross section is subcircular, but exhibits a marked flattening across the concave side of the conch and is slightly depressed. Near the

posterior end of the specimen the dorsoventral and lateral diameters are 47 mm. and 49 mm. respectively, while the dorsoventral diameter is 64 mm. at the base of the living chamber. Where the dorsoventral diameter is 47 mm. the siphuncle has a dorsoventral diameter of 12.7 mm. and a lateral diameter of 9.9 mm. It lies close to, but not in contact with, the concave surface of curvature.

Although the shell is well preserved in many places, no trace of fine surface ornamentation or growth lines is visible. Three shallow transverse constrictions occur, two close together behind the aperture and the other slightly posterior to the base of the body chamber.

The septa have a concavity of approximately two camerae. The sutures are straight and transverse. Measuring the depth of the camerae along the mid-lateral line, 11 camerae occupy a distance equal to the dorsoventral diameter.

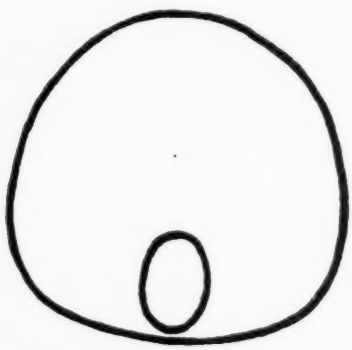


FIG. 2—Cross section of holotype of *Polyelasmoceras aduncum* Teichert and Glenister, n. gen., n. sp.

The septal necks are long and cyrtochoanitic with short brims. Connecting rings are thin, moderately inflated and have a large area of adnation. In a typical segment where the diameter of the septal foramen is 12.0 mm. and the height of the segment 3.3 mm., the connecting ring is inflated to the diameter of 14.4 mm., the lengths of the septal neck and brim are 1.3 mm. and .4 mm. respectively and the adnation area measures 1.1 mm. Actinosiphonate deposits appear in the siphuncle. They consist of numerous thin lamellae of irregular length, the largest measuring about one-third the diameter of the siphuncle. Most are straight, regular and unbranched, but a few branch and bifurcate to a small extent. In the younger part of the conch the lamellae of each siphuncular segment are discrete although aligned with those of the adjacent segments. They are thick at their anterior end but taper adapically. Towards the adapical end of the specimen the aligned lamellae fuse to give longer lamellae extending through many segments of the siphuncle.

The name is derived from Latin *aduncus*, hooked.

Occurrence.—Two hundred thirty feet above base of Taravale formation, Buchan Group, Middle Devonian. McLarty's Gully, 3 miles N. of Buchan, Gippsland, Victoria.

Genus BRACHYDOMOCERAS Teichert and Glenister, n. gen.

Genoholotype.—Brachydomoceras erectum Teichert and Glenister, n. sp.

Description.—Moderately large orthoconic brevicones with circular cross section. Body chamber short, aperture unconstricted, with shallow hyponomic sinus. Sutures straight and transverse. Septa shallow and camerae low.

Siphuncle close to but not in contact with ventral wall of conch. Siphuncular segments moderately inflated, but flatter on dorsal side than on ventral; maximum diameter one-ninth that of conch. Septal necks short, cyrtochoanitic, with short brims on ventral side, orthochoanitic on dorsal side. Endosiphuncular deposits actinosiphonate, consisting of irregularly alternating long and short, unbranched lamellae which are continuous through several segments. Longer lamellae may almost reach centre of siphuncle.

The name is derived from Greek *βραχύς*, short, *δόμος*, house.

BRACHYDOMOCERAS ERECTUM Teichert and Glenister, n. sp.
Plate 107, figures 1–3

Description of holotype (No. 48171, Mines Department of Victoria, Melbourne).—The holotype is an internal mould, with some of the shell attached, of an orthoconic brevi-

cone with circular cross section. The complete body chamber is present and only a few mm. of the apical portion of the phragmocone have been destroyed. In longitudinal section the walls of the body chamber are straight, but the walls of the phragmocone are gently convex. The body chamber is 21 mm. and the phragmocone 58 mm. long. Conch diameter is 50.0 mm. at the aperture, 45.5 mm. at the base of the living chamber and is estimated to be 23.5 mm. at the apical end of the specimen. The siphuncle is ventral. At the base of the living chamber it has a diameter of 4.8 mm. and is situated 2.2 mm. from the conch wall. At the apical end of the specimen it is almost in contact with the shell wall.

A shallow transverse constriction occurs in the wall of the body chamber just behind the aperture. It forms a shallowly rounded sinus across the venter and bears faint striations indicative of growth lines, suggesting the presence of a shallow hyponomic sinus. Low longitudinal ridges occur on the internal mould of the phragmocone but are absent on the wall of the body chamber where the shell is preserved.

Height of camerae is extremely variable. Successive heights in mm. beginning at apical end are 1.4, 1.5, 1.6, 1.9, 2.4, 2.3, 1.9, 3.2, 4.0, 4.5, 4.0, 2.6, 3.8, 2.7, 2.6, 3.2, 3.6, 2.8, 2.8. Septa average 1½ to 2 camerae in depth. Sutures straight and transverse. Cameral deposits absent.

Septa vary greatly in thickness in different parts of the conch. They are moderately thick near the dorsum, become quite thin in the middle of the conch, then thicken ventrally except for a rapid thinning at the septal necks. Measurements of thickness for a typical septum are 0.35 mm. near the dorsum, 0.1 mm. in the centre of the conch, 0.3 mm. adjacent to the septal neck, 0.2 mm. at the septal neck, and 0.35 mm. on the ventral side of the siphuncle. Septal necks short, cyrtochoanitic on the ventral side and orthochoanitic dorsally. The septum whose measurements are given above has a neck 0.6 mm. long with a brim 0.1 mm. long on the ventral surface and a straight neck lying at 70° to the septum on the dorsal side. Connecting rings are adnate only to the septal necks, but lie close to the adoral surface of the septum for a considerable distance on the ventral side of siphuncle. Connecting rings on the dorsal side are strongly inflated adjacent to the necks, but are flat in the middle; ventrally the connecting rings are uniformly inflated. In a segment where the septal foramen has a diameter of 2.35 mm., the greatest diameter of the segment is 4.0 mm.

Actinosiphonate deposits are present; they are simple lamellae which do not branch and may be continuous through several segments of the siphuncle. Long lamellae, which frequently reach the centre of the siphuncle, irregularly alternate with shorter lamellae.

Occurrence.—About 300 feet above top of Cave limestone, Buchan group; McLartys' Gully, 3 miles north of East Buchan eastern Victoria.

Genus MACRODOMOCERAS Teichert and Glenister, n. gen.

Genotype.—Macrodomoceras howitti Teichert and Glenister, n. sp.

Description.—Gently curved, rapidly expanding endogastric brevicones, with subcircular cross section, the concave venter being more sharply rounded than the dorsum. Siphuncle moderately small, the inflated segments almost touching the ventral wall of conch. Aperture with broad, but deep, hyponomic sinus.

Septa moderately concave. Suture has a bluntly pointed shallow saddle across the venter. Camerae shallow. Septal necks short and cyrtochoanitic, connecting rings thin with broad area of adnation. Actinosiphonate lamellae continuous through many segments. Long thick bipectinate siphuncular lamellae interspersed among more numerous short simple lamellae.

The name of the genus is derived from Greek *μάκρος*, long, and *δόμος*, house.

MACRODOMOCERAS HOWITTI Teichert and Glenister, n. sp.
Plate 106, figures 1–2;
plate 107, figures 4–5

Description of holotype (No. 47903, Mines Department, Melbourne).—The holotype is a well-preserved rapidly expanding brevicone which is gently curved endogastrically.

It is 48 mm. long, of which 28 mm. is body chamber. Near the adoral end of the specimen the dorsoventral and lateral diameters are 47 mm. and 46 mm. respectively, and at the apical end 25.5 mm. and 24 mm. The cross section is subcircular with the venter more sharply rounded than the dorsum. The siphuncle has a diameter equal to one-seventh the dorsoventral diameter of the conch and has inflated segments, many of which appear to touch the wall of the conch.

Fine growth lines are visible where the shell has not been destroyed. They exhibit a deep but broad lobe across the venter, indicating the presence of a prominent hyponomic sinus. This is confirmed by the undamaged portions of the aperture. Ill-defined longitudinal ridges appear both on the surface of the conch and on the internal mould, those on the latter being more pronounced and regular.

The septa have a concavity equal to the length of approximately two camerae. The sutures are straight and transverse except for a bluntly pointed shallow saddle across the venter. Measuring the depth of the camerae along the lateral midline, ten camerae occupy a distance equal to the dorsoventral diameter.

Siphuncular segments are strongly inflated. Septal necks are cyrtochoanitic and greatly variable in shape. Some are sharply recurved with the brims in contact with the adapical surface of the septa; others may be as long as one-sixth of the distance between two successive septa. The connecting rings are thin and adnate to the adoral surface of the septa on the ventral side for a distance equalling half the height of the camerae. Actinosiphonate deposits appear in the siphuncle. The siphuncular lamellae are numerous and continuous from one segment to the next. Thick, irregularly bipectinate lamellae, almost reaching to the centre of the siphuncle, are irregularly interspersed among much shorter simple lamellae.

This species is named in honour of A. W. Howitt, a pioneer geologist of Gippsland.

Occurrence.—Taravale formation, Buchan group. 355 feet above Cave limestone, McLarty's Gully, 3 miles N. of East Buchan, Gippsland, Victoria.

Family TROCHOLITIDAE
Genus HARDMANOCERAS Teichert and Glenister, n. gen.

Genotype.—Hardmanoceras lobatum Teichert and Glenister, n. sp.

Description.—Discoidal, evolute conchs with a slowly expanding whorl-section. All whorls in contact and slightly impressed dorsally. Whorl-section subrectangular and depressed. Flanks uniformly rounded, the venter slightly convex and the dorsum slightly concave. Mature specimens have about six whorls, at least one and a quarter of which are body chamber. Ribs prominent on the flanks, becoming faint as they cross the venter forming a deep V-shaped lobe. Siphuncle cylindrical, situated close to the dorsal side of the whorls. Septal necks short, orthochoanitic. Connecting rings thickened in early whorls but become thinner in the mature parts on the conch. Cameral deposits present, showing greatest development on dorsal side of siphuncle.

The generic name is given in honour of E. T. Hardman, who in 1881 published the first geological map of the Kimberley Division of Western Australia.

Affinities.—Hardmanoceras is a typical member of the Trocholitidae. It is distinguished from *Trocholites* by its less strongly depressed whorl cross section and the presence of prominent ribs. *Curtoceras* has a living chamber which at full maturity diverges from the preceding volution of the conch and does not develop the pronounced ribs found in *Hardmanoceras*.

HARDMANOCERAS LOBATUM Teichert and Glenister, n. sp.
Plate 107, figures 6–10

Description of holotype (No. 17,735, Bureau of Mineral Resources, Geology and Geophysics, Canberra.).—The holotype is a discoidal shell 51 mm. in diameter, consisting of five and a half slowly expanding whorls, one of which is body chamber. All whorls are in contact, and impressed dorsally. The first whorl is not well preserved, but it is probable that a small umbilical perforation was present. The whorl section is subrectangular and depressed, having a height of 6.0 mm. and a width of 10.1 mm.

near the end of the phragmocone. The flanks are gently and uniformly rounded, the venter almost flat, and the dorsum near the end of the phragmocone impressed to a depth of 0.7 mm.

Prominent ribs are present at all growth stages. They are strongest across the flanks, and become faint as they bend back to form a deep V-shaped lobe across the venter. The depth of this ventral lobe is approximately equal to the height of the whorl. The surface of the conch is covered with fine lirae. They are essentially transverse and parallel but frequently bifurcate and anastomose in an irregular manner similar to a finger print. This wrinkled layer probably corresponds to the "runzelschicht" described in many lower Paleozoic cephalopods. The sutures are simple, with shallow, gently rounded lobes across the dorsum and venter separated by saddles across the flanks.

The siphuncle has a diameter about one-fifth the height of the whorl and near the end of the phragmocone its dorsal surface is situated one-tenth of the height of the whorl from the dorsum.

Description of paratype (No. 17,736 Bureau of Mineral Resources, Geology and Geophysics, Canberra).—The paratype is a specimen consisting of three and a half whorls, one and a quarter of which are body chamber. It has been sectioned in the midplane. The siphuncle is cylindrical and orthochoanitic with septal necks stretching one fifth of the distance towards the preceding septum. Connecting rings reach from the tip of the septal neck to the preceding septal foramina. In the inner whorls the connecting rings are three times as thick as the septa but adorally they become thinner until in the last whorl of the phragmocone they have the same thickness as the septa. Cameral deposits are developed around the connecting rings and extend along both sides of the septa. The episeptal deposits have the greater development especially in the dorsal part of the camera when they may reach the dorsal wall and extend along it. The hyposeptal deposits only extend a shorter distance from the siphuncle. The siphuncle is almost in contact with the dorsal wall of the conch in the inner whorls, but moves ventrally in younger parts of the shell until at the end of the phragmocone its dorsal wall is separated from the wall of the conch by a distance equal to one-fourth of the siphuncle.

Occurrence.—Top of Stage III and bottom of Stage IV of Emanuel limestone, Emanuel Creek, Desert Basin, Western Australia. (See Guppy and Öpik, 1950, for details of locality and of stratigraphical subdivisions.)

Family RUTOCERATIDAE
Genus LITOGYROCERAS Teichert and Glenister, n. gen.

Genotype.—Litogyroceras spirale Teichert and Glenister, n. sp.

Description.—Large exogastric gyrocones, whorls free, the distance between them gradually increasing from apical to oral part of the conch. Whorl cross section subcircular, flattened dorsally. Shell surface smooth. Siphuncle small and almost in contact with ventral wall.

Septa highly concave, camerae deep. Suture consists of a shallow dorsal lobe, a pair of shallow lateral saddles and a deep narrow ventral lobe. Septal necks orthochoanitic, stretching one-third of distance to preceding septum.

The name of the genus is derived from Greek λιτός, smooth.

Affinities.—In general conch shape and in the position of the siphuncle this genus resembles members of the family Rutoceratidae from all of which, however, it differs in having a smooth shell.

LITOGYROCERAS SPIRALE Teichert and Glenister, n. sp.
Plate 108, figures 1–5

Description of holotype (Nos. 47579–47583, Mines Department, Melbourne).—The holotype is a poorly preserved exogastric gyrocone consisting of two and a quarter whorls forming a coil of maximum diameter of 89 mm. The body chamber is not preserved.

The umbilicus is probably perforate. The first whorl is in contact with the second whorl for about a quarter of its length, after that the second whorl becomes free and the distance between the whorls increases gradually to 4 mm. at the adoral

end of the specimen. The whorl cross section is subcircular but is slightly depressed and flattened across the dorsum. The siphuncle is small and almost in contact with the ventral wall of the conch.

The shell surface is smooth. Fine longitudinal striations appear on the internal mould.

Sutures have a shallow dorsal lobe, a pair of shallow lateral saddles and a deep narrow ventral lobe slightly more than one camera in depth. The septa are uniformly concave, and one camera in depth. The camerae are high.

Description of paratype (No. 47586, Mines Department, Melbourne).—The paratype is a well-preserved fragment 95 mm. long, 22 mm. of which is body chamber. The dorsoventral and lateral diameters are 40.5 mm. and 43.0 mm. respectively at the anterior end and 31.0 and 32.9 at the posterior end. The siphuncle has a diameter equal to one-thirteenth of the dorsoventral diameter.

Measuring the length of the camerae along the middle of the flanks, four camerae occupy a distance equal to the dorsoventral diameter. Cameral and siphuncular deposits are unknown.

The adoral half of the specimen has been sectioned in the dorsoventral mid-plane. The septal necks are short and straight, reaching one-third of the distance towards the preceding septum. On the ventral side the septal necks lie almost in contact with the shell wall for their whole length. Connecting rings are not preserved.

Occurrence.—On road from Buchan to Gelantipy, 2 miles due N.E. of Buchan bridge (3 miles along the winding road itself); in calcareous nodules in highest beds of Taravale formation, Buchan Group, Middle Devonian.

Bibliography

Barrande, J., 1866, Système Silurien du centre de la Bohême: vol. 2, 2 me. série, pls. 108–244, Prague.

——, 1868, Système Silurien du centre de la Bohême: vol. 2, 3 me. série, pls. 245–350, Prague.

——, 1870, Système Silurien du centre de la Bohême: vol. 2, 4 me. série, pls. 351–460, Prague.

——, 1874, Système Silurien du centre de la Bohême: vol. 2, texte, 3 me. partie, pp. 1–804, Prague.

Chapman, F., 1912, Newer Silurian fossils of eastern Victoria, Part 2: Geol. Surv. Vict., Rec., vol. 3, pt. 2, pp. 224–233, pls. 37–38.

——, 1914, Newer Silurian fossils of eastern Victoria, Part 3: Geol. Surv. Vict., Rec., vol. 3, pt. 3, pp. 301–316, pls. 46–61.

——, 1915, New and little known Victorian fossils in the National Museum, Part 17; Some Tertiary Cephalopoda: Roy. Soc. Vict., Proc., vol. 27 (new series), pt. 2, pp. 350–361, pls. 3–8.

Crick, G. C., 1894, On a collection of Jurassic Cephalopoda from Western Australia: Geol. Mag., vol. 1, dec. 4, pp. 385–441, pls. 12–13.

Etheridge, R. Jr., 1891, Contribution to the palaeontology of South Australia, No. 1; Description of some South Australian Silurian and Mesozoic fossils: Parl. Pap. S. Aust., No. 158, pp. 9–13, pls. 1–3.

——, 1893, Contribution to the palaeontology of South Australia, No. 5; Additional Silurian and Mesozoic fossils from Central Australia: Parl. Pap. S. Aust., No. 52, pp. 6–8, pl. 1.

——, 1894, Contribution to the paleontology of South Australia, No. 7; Further additions to the Lower Silurian fauna of Central Australia: Parl. Pap. S. Aust., No. 25, pp. 23–26, pl. 3.

——, 1901, Additional notes on the palaeontology of Queensland, Pt. 2: Queensland Geol. Surv., Bull. 13, pp. 1–37, pls. 1–4.

——, 1904, On the occurrence of a lituitean in the Upper Silurian rocks of Bowning, New South Wales: Aust. Mus., Rec., vol. 5, pt. 2, pp. 75–77, pl. 8.

——, 1905, Contribution to the palaeontology of South Australia, No. 14; Cretaceous fossils from Dalhousie Springs: Parl. Pap. S. Aust., No. 71, pp. 13–17, pls. 1–3.

Flower, R. H., 1939a, Study of the Pseudorthoceratidae: Paleont. Americana, vol. 2, no. 10, pp. 1–114, pls. 1–9.

——, 1939b, *Harrisoceras*, a new structural type of orthochoanitic nautiloid: Jour. Paleontology, vol. 13, pp. 473–480, pls. 49–50.

——, 1941, Notes on structure and phylogeny of eurysiphonate cephalopods: Paleont. Americana, vol. 3, no. 13, pp. 1–56, pls. 1–3.

——, 1943a, Investigations of actinosiphonate cephalopods: Bull. Amer. Paleont., vol. 28, no. 109, pp. 30–67, pls. 2–6.

——, 1943b, Annulated orthoceraconic genera of Paleozoic nautiloids: Bull. Amer. Paleont., vol. 28, no. 108, pp. 102–128.

——, 1946, Ordovician cephalopods of the Cincinnati region, Part I: Bull. Amer. Paleont., vol. 29, no. 116, pp. 1–656, pls. 1–43.

——, 1947, Holochoanites are endoceroids: Ohio Jour. Sci., vol. 47, pp. 155–172.

——, and Kummel, B., Jr., 1950, A classification of the Nautiloidea; Jour. Paleontology, vol. 24, pp. 604–616.

FOERSTE, A. F., 1924, Notes on American Paleozoic cephalopods: Denison Univ. Bull., Jour. Sci. Lab., vol. 20, pp. 193–267, pls. 21–42.

——, 1925, Notes on cephalopod genera; chiefly coiled Silurian forms: Denison Univ. Bull., Jour. Sci. Lab., vol. 22, pp. 1–69, pls. 1–24.

——, 1926, Actinosiphonate, trochoceroid and other cephalopods: Denison Univ. Bull., Jour. Sci. Lab., vol. 21, pp. 285–383, pls. 32–53.

——, and TEICHERT, C., 1930, The actinoceroids of east-central North America: Denison Univ. Bull., Jour. Sci. Lab., vol. 25, pp. 201–296, pls. 27–59.

GUPPY, D. J., and ÖPIK, A. A., 1950, Discovery of Ordovician rocks, Kimberley Division, W. A.: Aust. Jour. Sci., vol. 12, pp. 205–206.

HILL, D., 1942, Some Tasmanian Palaeozoic corals: Roy. Soc. Tas., Pap. Proc., 1941, pp. 3–11, pl. 2.

——, 1943, A re-interpretation of the Australian Palaeozoic record, based on a study of the rugose corals: Roy. Soc. Queensland, Proc., vol. 54, no. 6, pp. 53–66.

——, and EDWARDS, A. B., 1941, Note on a collection of fossils from Queenstown, Tasmania: Roy. Soc. Victoria, Proc., vol. 53 (new series), pt. 1, pp. 222–230, 1 pl.

HILLS, C. L., and CAREY, S. W., 1949, Geology and mineral industry: Aust. N. Zeal. Ass. Adv. Sci., Handbook of Tasmania, pp. 21–44.

JACK, R. L. and ETHERIDGE, R., JR., 1892, The geology and palaeontology of Queensland and New Guinea: Brisbane and London, pp. 1–768, pls. 1–68.

KOBAYASHI, T., 1940, On the Ordovician shelly faunas in the Southwestern Pacific Province: Jap. Jour. Geol. Geogr., Trans. and Abst., vol. 17, nos. 1–2, pp. 105–125.

KONINCK, L. G. DE, 1877, Recherches sur les fossiles paléozoiques de la Nouvelle-Galles du Sud (Australie): Mém. Soc. Roy. Sci. Liège, sér. 2, vols. 6, pp. 1–140, pls. 1–24.

MADIGAN, C. T., 1932, The geology of the Western Macdonnell Ranges, Central Australia: Quart. Jour. Geol. Soc. London, vol. 88, pp. 671–711, pls. 41–46.

MCCOY, F., 1876, Prodromus of the palaeontology of Victoria; dec. 4; Geol. Surv. Vict: pp. 1–32, pls. 31–40.

——, 1879, Prodromus of the palaeontology of Victoria; dec. 6; Geol. Surv. Vict: pp. 1–42, pls. 51–60.

REMELÉ, A., 1880 and 1889, Beschreibung und Abbildung einiger gekrümmter Silurcephalopoden aus norddeutschen Diluvialgeschieben: (Text pp. 1–43 and pls. 1–2 appeared first in "Festschrift f. d. 50-jähr. Jubelfeier d. Forstakad. Eberswalde," 1880, and were reprinted with some additions, in 1889, Jul. Springer, Berlin).

——, 1886, Einige Bemerkungen über die Systematik der Lituiten: Zeitschr. Dtsch. Geol. Ges., vol. 38, pp. 467–468.

SCHINDEWOLF, O. H., 1942a, Evolution im Lichte der Paläontologie, Bilder aus der Stammesentwicklung der Cephalopoden: Jen. Zeitschr. Naturw., Bd. 75, pp. 324–386.

——, 1942b, Discosoriden (Ceph., Nautil.) im deutschen Devon: Jb. Reichsstelle für Bodenforschung, Bd. 62, 1941, pp. 499–533, pls. 34-42.

SPATH, L. F., 1927, Revision of the Jurassic cephalopod fauna of Kuchh (Cutch): Palaeont. Indica, new series, vol. 9, mem. no. 2, pp. 1–71, pls. 1–7.

TATE, R., 1896, Palaeontology: Report on the work of the Horn Scientific Expedition to Central Australia, Part 3; Geology and Botany: London and Melbourne, pp. 97–116, pls. 1–3.

TEICHERT, C., 1930, Die Cephalopoden-Fauna der Lyckholm Stufe des Ostbaltikums: Pal. Zeitschr., vol. 11, pp. 264–312.

——, 1934, Einige actinoceroide Cephalopoden aus dänischen Diluvialgeschieben und aus dem Gotlandium Skandinaviens: Medd. fra Dansk Geol. Forening. København, Bd. 8, pp. 371–401, pls. 8–10.

——, 1939a, The nautiloid *Bathmoceras* Barrande: Roy. Soc. South Aust., Trans., vol. 63, no. 2, pp. 384–391, pl. 19.

——, 1939b, Nautiloid cephalopods from the Devonian of Western Australia: Roy. Soc. West. Aust., Jour., vol. 25, 1938–1939, pp. 103–121, pls. 1–2.

——, 1940, Actinosiphonate cephalopods (Cyrtoceroida) from the Devonian of Australia: Roy. Soc. West. Aust., Jour., vol. 26, 1939–40, pp. 59–75, pls. 1–4.

——, 1943, Eocene nautiloids from Victoria: Roy. Soc. Vic., Proc., vol. 55, pt. 2 (New Series), pp. 257–264, pl. 11.

——, 1944, The genus *Aturia* in the Tertiary of Australia: Jour. Paleontology, vol. 18, pp. 73–82, pls. 14–16.

——, 1947a, Notes on Eocene nautiloids from Victoria: Mining and Geol. Jour., vol. 3, pp. 40–43, 2 pls.

——, 1947b, New nautiloids from the older Tertiary of Victoria: Mining and Geol. Jour., vol. 3, pp. 48–51, 1 pl.

——, 1947c, Early Ordovician cephalopods from Adamsfield, Tasmania: Jour. Paleontology, vol. 21, pp. 420–428, pl. 58.

——, 1948, Middle Devonian goniatites from the Buchan District, Victoria: Jour. Paleontology, vol. 22, pp. 59–67, pl. 16.

——, 1949, Observations on stratigraphy and palaeontology of Devonian, western portion of Kimberley Division Western Australia: Bureau Min. Res., Geol. Geophy., Aust., report no. 2, pp. 1–55, pls. 1–6.

——, 1950, Discovery of Devonian and Carboniferous in the North-West Basin, Western Australia: Aust. Jour. Sci., 1949, vol. 12, no. 2, pp. 62–65.

——, 1951, The marine Permian faunas of Western Australia: Palaeont. Zeitschr., Bd. 24, Nr. 1/2, pp. 76–90

THOMAS, D. E., 1948, A critical review of the lower Palaeozoic succession of Tasmania: Roy. Soc. Vic., Proc., vol. 59, pt. 1 (new series), pp. 23–52.

ULRICH, E. O., FOERSTE, A. F., and MILLER, A. K., 1943, Ozarkian and Canadian cephalopods, Part II; Brevicones: Geol. Soc. America, Spec. Paper 49, pp. 1–240, pls. 1–70.

——, ——, ——, and FURNISH, W. M., 1942, Ozarkian and Canadian cephalopods, Part I; Nautilicones: Geol. Soc. America, Spec. Paper 37, pp. 1–157, pls. 1–57.

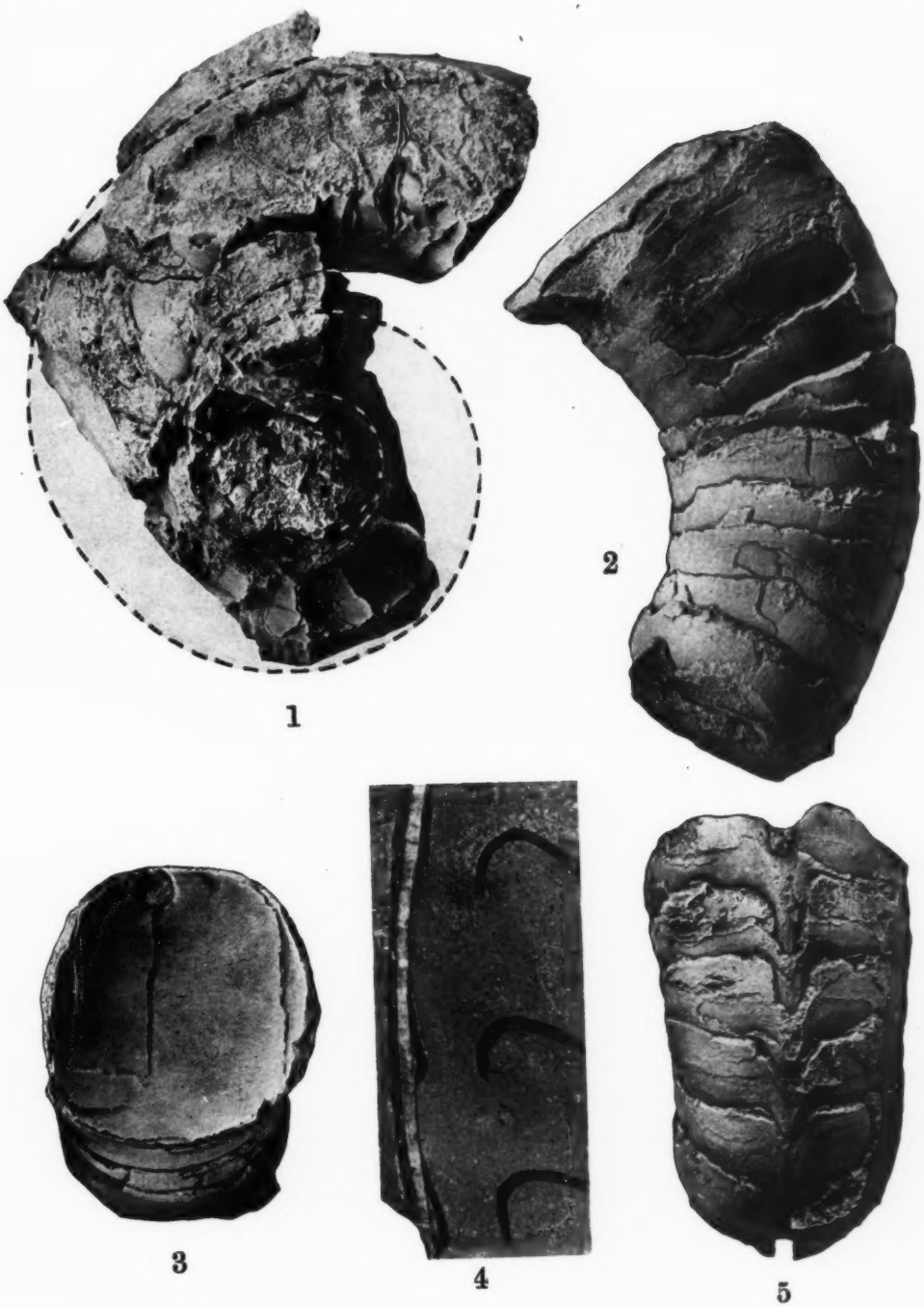
——, ——, ——, and UNKLESBAY, A. G., 1944, Ozarkian and Canadian cephalopods, Part III; Longicones and Summary: Geol. Soc. America, Spec. Paper 58, pp. 1–226, pls. 1–68.

WHITEHOUSE, F. W., 1936, The Cambrian faunas of north-eastern Australia, Parts 1 and 2: Queensland Mus., Mem., vol. 11, pt. 1, pp. 59–112, pls. 8–10.

MANUSCRIPT RECEIVED NOV. 30, 1951

EXPLANATION OF PLATE 108

FIGS. *1–5*—*Litogyroceras spirale* Teichert and Glenister, n. gen., n. sp. Devonian, eastern Victoria. *1*, lateral of holotype No. 47,579/83, ×1. *2–5*, paratype No. 47,586. *2*, lateral ×1; *3*, adoral ×1; *4*, section in dorsoventral mid-plane ×3; *5*, ventral ×1. (p. 749)



Teichert and Glenister, Australian nautiloids

2 1

Caster and Macke, Ohio Ordovician aglaspid merostome

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 753–757, PL. 109, 1 TEXT FIG., SEPTEMBER 1952

AN AGLASPID MEROSTOME FROM THE UPPER ORDOVICIAN OF OHIO

KENNETH E. CASTER AND WILLIAM B. MACKE
University of Cincinnati

ABSTRACT—A new genus and species of Aglaspida, *Neostrabops martini* Caster and Macke, is the first post-Cambrian record of the class. It comes from the Upper Ordovician near Cincinnati, Ohio. The closest resemblance in form is to the enigmatic *Strabops* of the Upper Cambrian of Missouri.

INTRODUCTION

THE Aglaspida have been considered one of the most reliable index-fossil groups for the recognition of the North American Middle and Upper Cambrian; however, the recent discovery of a representative of the class in the Upper Ordovician of Ohio illustrates how little we know about the real versus the apparent ancient ranges of organisms. What are the probabilities involved in the rare accident of fossilization anyway? What size population of any species, endowed with the usual prerequisites for preservation, must there be in any setting that geologically useful representatives may be fossilized? Of immediate interest in connection with this maverick merostome, which was still living in the Cincinnati seas tens of millions of years after the supposed extinction of all its kind, is the question: how terminally definitive were the various geological "extinctions"? Obviously, hosts of lineages of organisms have become unquestionably genetically extinct throughout geologic time; they left no descendants, in contrast with those lineages which were taxonomically "exterminated" by evolution into new species and genera. But such anachronisms as this aglaspid—and geologic literature contains many comparable records—suggest the probability that the apparent extinctions of the geologic record anteceded by many millions of years the actual biological extinction of which the fossil record was prenuncial.

May not geological extinction reflect only a critical population point? When populations dropped below that critical level, probability would seem to make the odds against fossilization so high that when these are added to the odds involved in the probability of survival of the fossil until the present, plus those factors related to the probability of human discovery of this fossil during the last century and a half (the maximum age of organized fossil-hunting), the "geologic extinction" of most ancient organisms would constitute their terminal record. Yet the fact that survivors do occasionally turn up, and millions of years late, would tend to support the thesis that the nature of the geologic record itself tends to magnify the element of catastrophism in biologic history.

Moreover, the so-called "explosiveness" in the (geologically) sudden appearance of faunas may be in part due to the same critical numerical factor in populations.

It might at first seem strange that this new organism only now turns up in a fauna so well-known and so long collected as the Maysville of the Cincinnati Uplift. As a matter of fact, it comes from one of the most richly fossiliferous and most ardently collected members of that formation. Yet it is this very member, and at the site of the present discovery, that has yielded most genuine novelties in recent years.

The new findings in this traditional terrane have been of two origins: first come the new

EXPLANATION OF PLATE 109

FIG. *1*—*Neostrabops martini* Caster and Macke, n. gen., n. sp. From the Upper Ordovician, Clermont County, Ohio. ×1. (p. 754)

2—The same, enlarged to show the details of the eye-lobes and mold of the ventral surface of the dorsal shield which was apparently pustulose. (p. 754)

genera and species which result from the winnowing process of modern taxonomy; old categories were too broadly conceived, and fractionation results. But like every other classic fossil-collecting area, and especially those where the preservation of the fossils is superb, and they occur in great abundance, those horizons which yield such spoils—the so-called "butter layers"—have received almost all the attention. From such the main mass of the classic fauna has been derived. Those layers less abundantly endowed, or less satisfactory in preservation, have been neglected. Probably more than half the Cincinnatian stratigraphic column falls into this category of neglected, "barren beds." Even in the extravagantly richly fossiliferous Corryville, member, whence comes the present fossil, this would be the case. In recent years the systematic examination of these neglected beds has been paying off in novelties, of which the present example is one.

The Corryville exposure on Stonelick Creek, Clermont County, Ohio, is near the crest of the Cincinnati arch. There may be some connection between this structural fact and the unusually silty nature of the formation there. At any rate, on Stonelick the upper Corryville contains many discontinuous greenish-weathering calcareous siltstone bands, which contain up to 10% quartz silt-size particles. The abundantly fossiliferous beds are intercalated limy muds and calcarenites. The silty layers carry only sparse faunas, and fall into the neglected category. The particular bed[1] from which the present organism came is about two to three inches in thickness, and lenticular. It overlies a fine calcarenite of fossil fragments and underlies blue calcareous mudstone. The commonest fossils in the band are burrowing pelecypods and *Byssonychia;* orthoceroid cephalopods are also present; the silts show much evidence of subsurface burrowing by marine worms.

The present specimen was collected during a paleontology class excursion to Stonelick in the fall of 1950. Mr. Wayne Martin, one of the students, espied a "mighty curious trilobite," which, with less than the usual pedagogic persuasion, became the basis for this paper. Martin's reward, if such it may be called, lies in the specific name appended to his holotype, now in the University of Cincinnati Museum collection. Despite enthusiastic searching of the layer then and several times since, no additional examples of the curious fossil have turned up.

[1] Stonelick Creek is on the Batavia topographic quadrangle; the Corryville crops out at the crossing of Ohio State Highway 131, both above and below the bridge. The aglaspid site is about 250 yards downstream from the highway, on the southwest side of the stream. This is at the first ford of the wagon trail which follows the creek. The precise horizon is about 3 feet above low water of the creek in mid-summer. This greenish band can be traced in the vertical cut-bank downstream and opposite the discovery site. The same facies of silty beds reoccurs through quite a thickness of the local expression of the Corryville.

Genus NEOSTRABOPS Caster & Macke, n. gen.

Genotype: Neostrabops martini Caster and Macke, n. sp. Upper Ordovician (Cincinnatian series, Maysville subseries, Corryville member), Clermont County, Ohio.

Among the specific traits to be described below, the characteristics of generic significance are: elliptical body; lens-shaped carapace (possibly emarginate behind), with subquadrate glabellar area in low relief; eye-lobes anteromedian and apparently indications of anteriorly converging reniform eyes which were narrowest toward the front; a deep occipital furrow is extended across the bases of the cheeks; the furrow swings forward on the glabellar area, possibly indicating a corresponding emargination of the posterior boundary of the carapace; thoracic segments unequal in length and distance of overlap; without pleural spines; 11 in number, apparently. Telson unknown.

Comparisons with other genera are given under "remarks," below.

NEOSTRABOPS MARTINI Caster & Macke, n. sp.

Figure 1; plate 109, figures 1, 2

Known from the holotype only (University of Cincinnati Museum No. 25569).—This consists of the ventral mold surface of an articulated dorsal shield made up of a

cephalon (carapace) and most of 10 segments.

As seen in the illustrations, the body is oval in outline, without any lateral projections. It tapers slightly posteriorly. There is a broad rachis which creates obscure trilobation; the axis is more sharply delimited on the cephalon than elsewhere. The general aspect is one of smoothness and lack of "ornament." However, the whole surface of the mold is delicately punctose, which presumably reflects a finely granular or pustulose inner surface to the presumably phosphatic integument, none of which is preserved. The outer mold was not recovered, thus the nature of the outer surface is unknown.

Carapace.—The cephalon or carapace is lens-shaped and very short and transverse, being considerably less in width than the adjacent thoracic segment. There is no suggestion of genal spines. The posterior margin is not preserved; it may possibly have been medially emarginate, to correspond to the trend of a deep furrow which crosses both rachis and cheeks and sets off a broad posterior "occipital" band of the cephalon.

The medial area, or glabellar region, is broadly elevated and set off from the cheeks by relatively steep slopes. Prominent reniform bosses protrude anterolaterally from the glabellar area. These are assumed to be the eye-lobes. No signs of the actual eyes are preserved, however. The lobes extend to within 2 mm. of the anterior margin and are separated by a little less than the length of one lobe. No evidence of ocelli observed. No furrows or other markings are seen on the glabella. Cheeks smooth and unfurrowed. Anterior margin smoothly rounded.

Abdomen.—The abdomen consists of 10 known freely articulating segments. The fourth and fifth segments represent the greatest width of the organism. Lateral margins of all segments are smoothly arcuate, the posterior corners being only slightly acute, and in no sense produced as pleural spines. Although the specimen shows some torsion, especially toward the rear, it is apparently possible to judge life relations between the first eight segments very accurately. The third and fourth abdominal segments are essentially transverse, and their margins are essentially rectilinear and parallel. The anterior two segments grow progessively more arcuate toward the head-shield, whereas the posterior five segments are ever more arcuate posteriorly. The last segment is so crumpled that the posterior margin is not observable. On the assumption that our specimen was organized like other Aglaspida, the 11th segment and telson are missing.

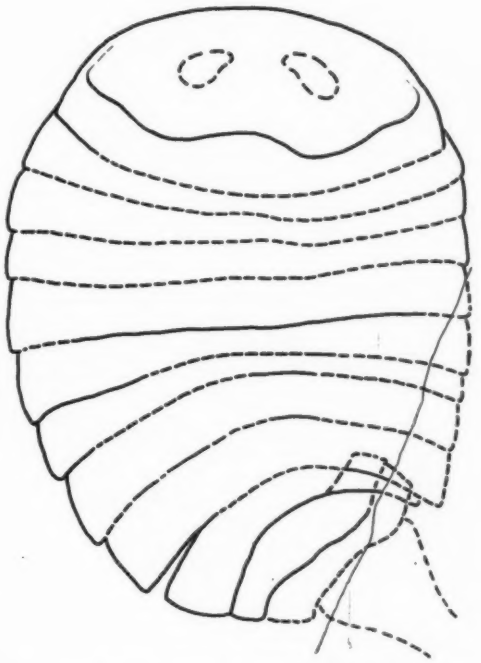


FIG. *1*—Outline tracing and restoration of exfoliated portions of the holotype of *Neostrabops martini* Caster & Macke. See plate 109 for actual dimensions.

The overlap of the segments is greatest along the rachis in segments 1, 2, 5 and 6. In the other segments it is essentially uniform along the width of the segments. The first segment underlies the carapace by about one-third the length of the segment. The articulating mechanism consists of a transverse ridge near the front margin of each segment which engages a corresponding groove in the inferior surface of the overlapping segment. In the photograph it will be noted that most of the segments are broken off along the articulation, hence the

broken lines in the text figure for restoring the margins of the segments.

Dimensions

Median length of specimen (to end of 10th segment), 35 mm.
Maximum width (4th and 5th abdominal segments), 28 mm.
Carapace width, 24 mm.
Carapace length (approx.), 16 mm.

Occurrence.—In the upper part of the Corryville member, McMillan formation, Maysville subseries, Cincinnatian series, Upper Ordovician, on Stonelick Creek, Clermont County, Ohio. The matrix is a greenish-weathering calcareous and silty bed, 2–3 inches thick. Approximately 10% quartz silt is present in the layer.

Remarks.—Closer similarity in organization exists between *Neostrabops martini* and *Strabops thacheri* Beecher (1901) of the Missouri Upper Cambrian than elsewhere. The assignment of *Neostrabops* to the Aglaspida is based on this similarity. This means, of course, acceptance of Raasch's (1939) interpretation of the enigmatic Cambrian genus, of which only the holotype is known. Although Beecher interpreted his genus as an eurypterid, Raasch points out that at the turn of the century this was really the only comparison possible due to the largely erroneous and quite incomplete knowledge of the genus *Aglaspis*. This remained the state of affairs until Raasch's classic restudy of the genus and its relatives. The interpretation of *Strabops* as an eurypterid had been fortified by the work of Clarke and Ruedemann (1913). In their great eurypterid monograph they stressed its supposed eurypterid traits. Raasch, however, carefully reexamined the holotype material, and found the Clarke and Ruedemann modifications of Beecher's original analysis unwarranted; this entailed a restoration of the eyes to the position Beecher had indicated, and a reaffirmation of his segment count. In both respects, Beecher's description fitted the modern characterization of the Aglaspida, rather than the Eurypterida. Størmer (1944), in his broad survey of the merostomes, accepts Raasch's classification of the genus.

Strabops and *Neostrabops* are unique among the aglaspids in having a short elliptical head which is conspicuously less than the greatest width of the dorsal shield; likewise in their lack of lateral spines on both the carapace and abdominal pleurae. The two genera appear to have essentially similarly placed and shaped eyelobes, of the aglaspid type. (Clarke and Ruedemann were mistaken, according to Raasch, in their relocation of the eyes of *Strabops* to the pleural area of the carapace.) The division of the abdomen into an anterior and posterior region in *Neostrabops*, which may not be true of *Strabops*, is not aglaspid, however; nor is the externally smooth integument in both genera.

The two genera differ in the character of the glabellar area: quadrate glabellar elevation of *Neostrabops* versus the apparently undefined glabellar region in *Strabops*. The conspicuous occipital furrow which reaches across the whole posterior width of the carapace of *Neostrabops* is unknown in the Cambrian genus. (The line drawn on the posterior carapace by Clarke and Ruedemann in their figure to represent the anterior margin of the supposed first abdominal segment Raasch failed to discover. Such a line might be interpreted from the Clarke and Ruedemann drawing to represent the analogue of the *Neosirabops* furrow.) Ocelli are apparently absent in both genera, although Beecher thought he detected two in the median area of his genus; an interpretation Raasch could not support. Beecher described surface scales on the posterior edges of the *Strabops* abdominal segments; no evidence of such ornament is known on the Ordovician specimen. Nor are the pustules on the ventral surface of the dorsal shield of *Neostrabops* reported from the Cambrian form. *Neostrabops* is considerably more ovate in body form, and shows more closely appressed tergites. However, this may be in part due to the larger size (older?) of *Strabops*, and to somewhat greater distortion.

The aglaspids proper are laterally more spinose than either of these genera, both at the genal angles and on the pleural terminations of the abdomen. Moreover, the aglaspid pleurae are generally trilobitoid in their possession of anterior gliding surfaces which neither *Strabops* nor *Neostrabops* possesses. In all probability these two genera should have separate family assignment in the Aglaspida, if, indeed, they are genuine

members of this class. If they are not aglaspids, however, there is no class of Arachnomorpha now available to them.

BIBLIOGRAPHY

BEECHER, C. E., 1901, Discovery of eurypterid remains in the Cambrian of Missouri: Amer. Journ. Sci., vol. 12(4), pp. 364–366, pl. 7.

CLARKE, J. M. and RUEDEMANN, R., 1913, The Eurypterida of New York: N. Y. State Mus. Mem. 14, 2 vols.

RAASCH, G. O., 1939, Cambrian Merostomata: Geol. Soc. Amer., Spec. Paper 19, 146 pp. 21 pls.

STØRMER, L., 1944, On the relationships and phylogeny of fossil and recent Arachnomorpha: Skrift. ut. av Det Norsk Vidensk.-Akad. i Oslo, I Math.-Naturv. Kl. 5, 158 pp., ill.

MANUSCRIPT RECEIVED AUGUST 2, 1951

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 758–760, PL. 110, SEPTEMBER 1952

A NEW UPPER CRETACEOUS AMMONITE GENUS FROM WYOMING AND UTAH

W. A. COBBAN
U. S. Geological Survey, Washington, D. C.

ABSTRACT—The new genus *Pseudobaculites* and the species *P. nodosus* and *P. wyomingensis* from rocks of Niobrara age (Santonian) in Wyoming and Utah are described.

INTRODUCTION

COLLECTIONS of fossils from six localities in Wyoming and two in Utah made by members of the U. S. Geological Survey have yielded fragments of an aberrant ammonite for which the new genus *Pseudobaculites* is erected. Five of the collections are from the Wind River Basin of west-central Wyoming, where the genus occurs in the Cody shale 500 to 1,500 feet above the base. The associated fossils are of about middle Niobrara age (early Santonian). A single fragment has been collected 500 feet above the base of the Cody shale in northwestern Wyoming associated with fossils that suggest a Niobrara age slightly older than the collections from the Wind River Basin. In northeastern Utah the genus occurs 800 to 900 feet above the base of the Mancos shale associated with fossils of late Niobrara age.

COLLECTING LOCALITIES

The associated fossils that are important in dating the enclosing rocks are listed along with the species of *Pseudobaculites*.

U.S.G.S. Mesozoic locality 21096.—Two miles northeast of Lander, in the NW¼ sec. 25, T. 2 S., R. 1 E., Fremont County, Wyoming. About 500 feet above the base of the Cody shale.

Pseudobaculites nodosus Cobban
Baculites asper Morton
Baculites codyensis Reeside

U.S.G.S. Mesozoic locality 21097.—Ten miles northwest of Lander, in the SW¼NE¼NE¼ sec. 25, T. 1 S., R. 1 W., Fremont County, Wyoming. From calcareous concretions 800 feet above the base of the Cody shale.

Inoceramus stantoni Sokolow
Pholadomya papyracea Meek and Hayden
Pseudobaculites nodosus Cobban
Baculites asper Morton
Baculites codyensis Reeside
Phlycticrioceras oregonense Reeside
Binneyites parkensis Reeside
Scaphites binneyi Reeside
Texanites sp.

U.S.G.S. Mesozoic locality 23095.—Forty-five miles north of Lander, on East Sheep Creek, in the SW¼NE¼SW¼ sec. 14, T. 6 N., R. 2 E., Fremont County, Wyoming. From calcareous concretions 535 to 550 feet above the base of the Cody shale.

Pseudobaculites nodosus Cobban
Baculites asper Morton
Scaphites binneyi Reeside

U.S.G.S. Mesozoic locality 23100.—Forty-five miles north of Lander, on East Sheep Creek, in the SE¼SW¼ sec. 14, T. 6 N., R. 2 E., Fremont County, Wyoming. From calcareous concretions 780 to 790 feet above the base of the Cody shale.

Inoceramus stantoni Sokolow
Pseudobaculites wyomingensis Cobban
Baculites asper Morton
Baculites codyensis Reeside
Phlycticrioceras oregonense Reeside
Scaphites depressus Reeside
Texanites shoshonensis (Meek)

U.S.G.S. Mesozoic locality 21748.—Ten miles north of Dubois, in the SE¼SW¼SE¼ sec. 23, T. 43 N., R. 107 W., Fremont County, Wyoming. About 1,500 feet above the base of the Cody shale.

Inoceramus stantoni Sokolow
Pseudobaculites wyomingensis Cobban
Baculites asper Morton
Baculites codyensis Reeside
Scaphites interjectus Reeside

U.S.G.S. Mesozoic locality 21497.—East Fork of Arizona Creek, about in the NE¼SW¼ sec. 14, T. 47 N., R. 115 W. (unsurveyed), Teton County, Wyoming. About 516 feet above the base of the Cody shale.

Inoceramus cf. *I. undabundus* Meek and Hayden
Pseudobaculites sp.

Baculites asper Morton
Scaphites ventricosus Meek and Hayden

U.S.G.S. Mesozoic locality 21427.—Ashley Creek, 3 miles west of Jensen, in sec. 24, T. 5 S., R. 22 E., Uintah County, Utah. About 800 feet above the base of the Mancos shale.

Pseudobaculites cf. *P. wyomingensis* Cobban
Baculites codyensis Reeside
Clioscaphites vermiformis (Meek and Hayden)

U.S.G.S. Mesozoic locality 23251.—Seven miles southeast of Jensen, in sec. 12, T. 6 S., R. 23 E., Uintah County, Utah. In the Mancos shale 907 feet above the top of the Frontier sandstone member.

Pseudobaculites wyomingensis Cobban
Baculites asper Morton
Baculites codyensis Reeside

SYSTEMATIC DESCRIPTIONS

Family BACULITIDAE

Genus PSEUDOBACULITES Cobban, n. gen.

Type species: *Pseudobaculites nodosus* Cobban, n. sp.

Shell straight with rapid taper; cross section oval to nearly elliptical; venter ordinarily with broad conspicuous undulations. Flanks smooth or with a row of nodes on the dorsal slope. Suture complex, with six saddles and six lobes, the lobes symmetrically bifid except the dorsal lobe, which is long, narrow, and undivided; saddles bifid, with the first and second lateral saddles very asymmetrically bifid.

The genus closely resembles *Baculites* in its straight shell, its cross sections, and its general sculpture. It differs in the greater taper, suture with asymmetrically bifid saddles, and in many specimens the broadly undulated venter. It differs strikingly from the associated species of *Baculites*—*B. asper* Morton and *B. codyensis* Reeside as described by Reeside (1927, p. 4, pl. 1, figs. 19–24; pl. 2, figs. 1–19). These are much smaller shells that taper less and have much simpler sutures. Only *Baculites compressus* Say as figured by Meek (1876, pp. 400–404, pl. 20, figs. 3a–c, text figs. 55, 56) and *B. hochstetteri* Liebus (1902, pp. 119, 120, pl. 6, figs. 4–6, text fig. 2) compare somewhat favorably by their rapid taper and complex sutures, but these species lack asymmetrically bifid saddles and broadly undulating venter. Many species of *Baculites* have undulated venters, but the undulations are ordinarily closely spaced. An exception is *B. minerensis* Landes (1940, pp. 166, 167, pl. 6, figs. 7, 8) from the Pakowki shale of Alberta, which has widely spaced rounded swellings along the venter.

Pseudobaculites is easily distinguished from other straight or nearly straight Cretaceous ammonite genera. *Lechites* Nowak (1908, p. 350) has the aperture turned toward the antisiphonal side, and the shell is sculptured with closely and regularly spaced siphonal ribs. *Sciponoceras* Hyatt (1894, pp. 578, 579) has constrictions, and in addition, an aperture directed toward the antisiphonal side. *Bochianites* Lory (1898, p. 133) has four lobes and saddles in the suture. *Euhomaloceras* Spath (1926, p. 80) has a gently curved living chamber. *Eubaculites* Spath (1926, p. 80) is a carinate form.

PSEUDOBACULITES NODOSUS Cobban, n. sp.

Plate 110, figures 1–10, 17, 18

Shell in early growth stages gently tapering; at later stages rapidly tapering. Cross section moderately to broadly ovate. Sculpture consists of large conspicuous more or less widely spaced round to arcuate nodes on the antisiphonal half of the sides. These may pass into ribs that cross the ventral part of the flanks with a strong forward inclination. The distance between nodes is approximately equal to the diameter of the shell between the nodes. The venter is conspicuously undulated, with each undulation apparently corresponding to a node. The smallest individual at hand, 6 mm. in diameter, clearly shows an undulating venter, but the lateral nodes are weak and consist of broad, rounded swellings. The largest specimen studied is a living chamber attaining a diameter of 20 mm. The holotype, however, is a septate fragment 16 mm. in diameter at the larger end, which doubtless came from a specimen greater than 20 mm. in diameter. It has a feature not seen on other specimens. The dorsolateral nodes are elongate and slightly arched, with the concavity on the side toward the aperture. An inconspicuous low area on each node divides it into two parts, with the ventral part the higher (pl. 110, fig. 4).

The suture is complex. The lateral lobes are nearly equal in size and symmetrically

bifid. The two terminal branches of each are markedly constricted at their bases, as in the suture of *Baculites compressus* Say. The first and second lateral saddles, which are nearly equal in size, are very asymmetrically bifid, the larger part of each lying adjacent to the first lateral lobe. The third lateral saddle is small and symmetrically bifid.

Remarks.—This is an extremely variable species. The nine specimens at hand have dorsolateral nodes that range from the arcuate bipartite nodes of the holotype to high round tubercles and low, broad swellings. Two of the specimens have nearly smooth venters; the rest have broadly undulated venters. The cross sections range from oval to elliptical, and some specimens have the flanks constricted near the venter.

Types.—Holotype, USNM 108209; figured paratypes, USNM 108210, 108211, 108212; unfigured paratypes, USNM 108213, 108214, 108215, 108216.

Pseudobaculites wyomingensis Cobban, n. sp.

Plate 110, figures 11–16, 19–21

This species differs from *P. nodosus* in its larger size, compressed nearly elliptical cross section, and smooth flanks. The smallest specimen examined is a crushed individual, with diameter of the small end about 6 mm. The largest specimen is a septate fragment 42.5 mm. in diameter (pl. 110, figs. 19–21). The suture is that of the genotype.

The holotype is a fragment 58 mm. long that retains a small part of the living chamber. At the beginning of the living chamber the specimen is 22 mm. in diameter and 12.6 mm. in width. The flanks are slightly constricted near the venter. Aside from a few weak undulations, the venter is smooth.

Remarks.—This species is represented in the collections by six specimens. Only three show much of the venter, which lacks the large conspicuous undulations that are so characteristic of *P. nodosus*. The largest specimen shows a very rapid taper of 15 degrees in contrast to 7 degrees for the smallest and 9 degrees for the holotype.

Types.—Holotype, USNM 108217; figured paratypes, 108218, 108219; unfigured paratypes 108220, 108221, 108222.

References

Hyatt, Alpheus, 1894, Phylogeny of an acquired characteristic: Am. Philos. Soc. Proc., vol. 32, pp. 349–647, pls. 1–14, text figs. 1–19.

Landes, R. W., 1940, Paleontology of the marine formations of the Montana group; in Geology of the southern Alberta plains: Canada Geol. Survey Mem. 221, pp. 129–223, pls. 1–8.

Liebus, Adalbert, 1902, Über einige Fossilien aus der karpathischen Kreide: Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, vol. 14, pp. 113–130, pl. 6, text figs. 1, 2.

Lory, P., 1898, Sur le Crétacé inférieur du Dévoluy et des régions voisines: Bull. Soc. Géol. France, ser. 3, tome 26, pp. 132–138.

Meek, F. B., 1876, Invertebrate Cretaceous and Tertiary fossils of the upper Missouri country: U. S. Geol. Survey Terr. Rept., vol. 9, pp. I–LXVI, 1–629, 45 pls., 85 text figs.

Nowak, Jean, 1908, Untersuchungen über Cephalopoden der oberen Kreide in Polen, Teil 1, Genus *Baculites* Lamarck: Acad. Sci. Cracovie Bull. internat., année 1908, pp. 326–353, pl. 14, text figs. 1–12.

Reeside, J. B., Jr., 1927, Cephalopods from the lower part of the Cody shale of Oregon Basin, Wyoming: U. S. Geol. Survey Prof. Paper 150 A, pp. 1–10, pls. 1–8.

Spath, L. F., 1926, On new ammonites from the English chalk: Geol. Mag., vol. 63, pp. 77–83.

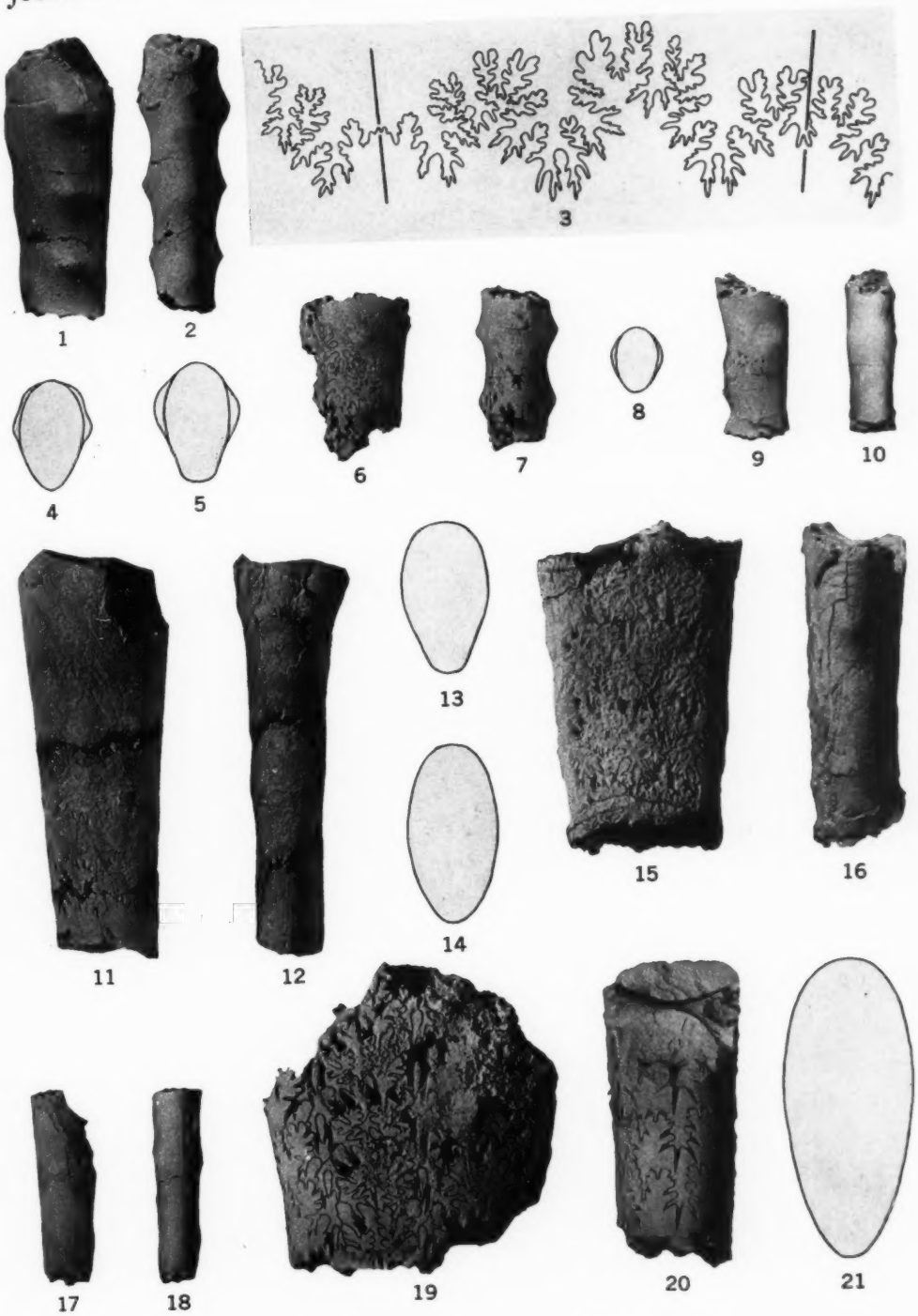
Manuscript received June 4, 1951

Publication authorized by the Director, U. S. Geological Survey

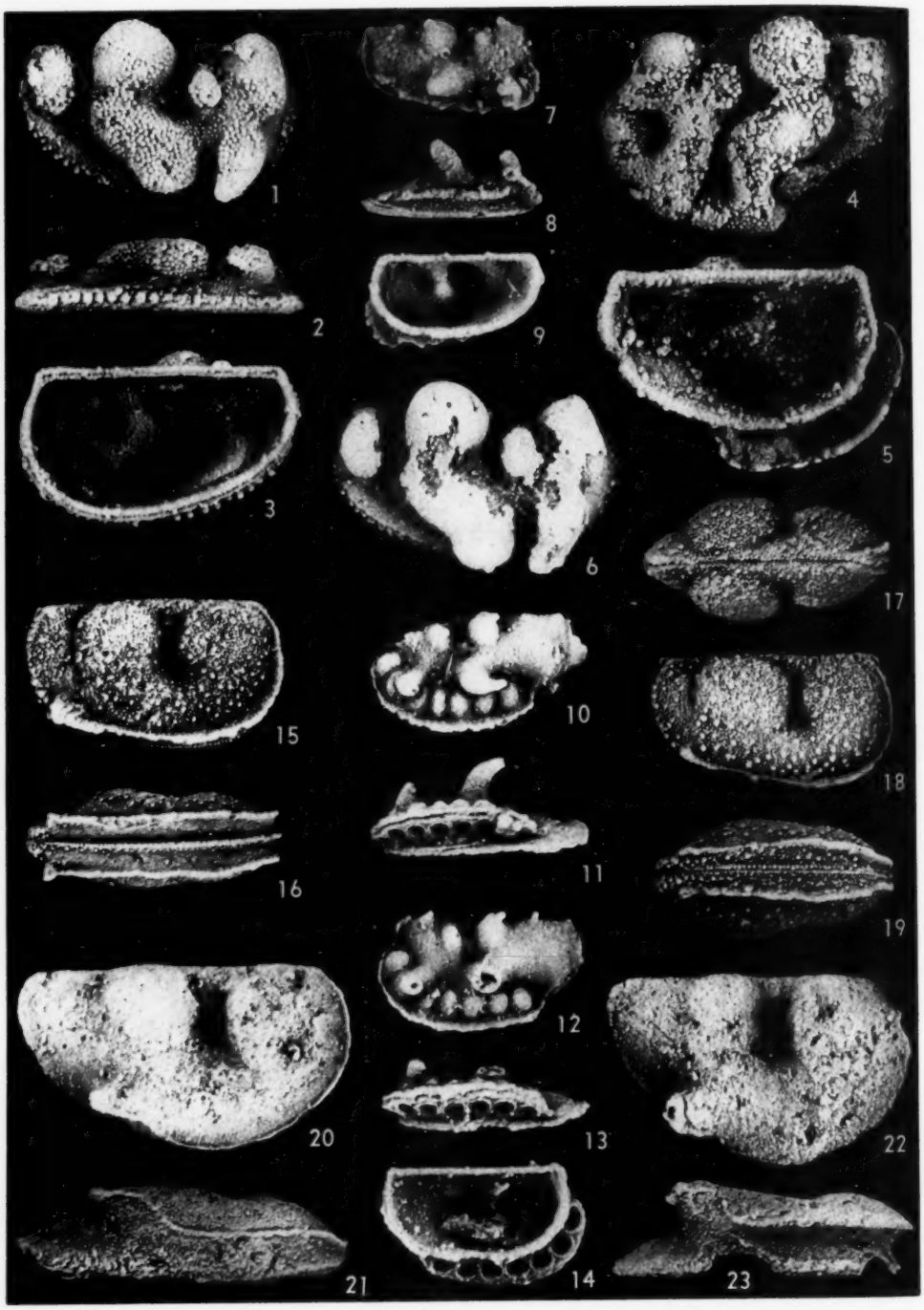
Explanation of Plate 110

Figs. *1–10, 17, 18—Pseudobaculites nodosus* Cobban, n. sp. *1–4*, Side and siphonal views (×1), suture (×3), and cross section (×1) at diameter of 15 mm. of the holotype, USNM 108209 (USGS Mes. loc. 21096); *5–7*, cross section (×1) at diameter of 16 mm., and side and antisiphonal views (×1) of a paratype, USNM 108210 (USGS Mes. loc. 21097); *8–10*, cross section (×1) at diameter of 9 mm., and side and antisiphonal views (×1) of a paratype, USNM 108211 (USGS Mes. loc. 23095), that has a conspicuous undulating venter; *17, 18*, side and antisiphonal views (×1) of a small paratype, USNM 108212 (USGS Mes. loc. 21097). (p. 759)

11–16, 19–21—Pseudobaculites wyomingensis Cobban, n. sp. *11–13*, Side and antisiphonal views (×1) and cross section at diameter of 21 mm. of the holotype, USNM 108217 (USGS Mes. loc. 21748); *14–16*, cross section (×1) at diameter of 24.5 mm. and side and siphonal views (×1) of a paratype, USNM 108218 (USGS Mes. loc. 23100); *19–21*, side and antisiphonal views (×1) and cross section (×1) at diameter of 40.5 mm. of the largest known specimen, USNM 108219 (USGS Mes. loc. 23100).



Cobban, new Cretaceous ammonite genus



Kesling, and Kesling and Tabor, new Devonian ostracods

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 761–763, PL. 111, SEPTEMBER 1952

TWO NEW SPECIES OF OSTRACODS FROM THE GENSHAW FORMATION (MIDDLE DEVONIAN) OF MICHIGAN

ROBERT V. KESLING AND NORMAN L. TABOR
Museum of Paleontology and Geology Department, University of Michigan, Ann Arbor

ABSTRACT—Two new species of hollinid ostracods are described from the Genshaw formation, Middle Devonian Traverse group of Michigan. Both species exhibit dimorphism. One belongs to the genus *Winchellatia*, previously described only from an Ordovician formation.

INTRODUCTION

THE ostracod fauna of the Genshaw formation of Michigan differs greatly from that of the formations below and above. The two new species described in this paper are of particular interest because they show kinds of dimorphism not recognized previously in Devonian hollinid ostracods.

All types are catalogued and deposited in the Museum of Paleontology of the University of Michigan, Ann Arbor, Mich.

LOCALITY

All specimens on which these species are based were collected by the senior writer from dark gray shale containing numerous *Cyrtina umbonata alpenensis* Hall and Clarke, three feet below the black Killian's limestone member, on the west side of Long Lake about one-half mile south of LeRoy's Resort, at the junction of West Long Lake Road and the entrance to Martin's Resort, Presque Isle County, Michigan.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA
Class CRUSTACEA
Order OSTRACODA
Superfamily BEYRICHIACEA
Family HOLLINIDAE Swartz 1936
Genus CTENOBOLBINA Ulrich 1891
CTENOBOLBINA MEGALIA Kesling & Tabor, n. sp.
Plate 111, figures 15–19

Description of male.—Carapace nearly equivalved, the left valve overlapping the right around free border. Valves elongate, subelliptical in lateral view. Hinge line straight; anterior and posterior borders subrounded; ventral border gently curved. Anterior lobe large, confluent with ventral lobe; front posterior lobe inflated, about one-third the length of the valve, tangent to dorsal border, with distinct anterior, dorsal and posterior boundaries, confluent ventrally with the ventral lobe; rear posterior lobe low, with a distinct anterior boundary at its junction with the front posterior and

EXPLANATION OF PLATE 111

All figures ×30.

FIGS. *1–6—Hollina insolens* (Ulrich), *1–3*, lateral, ventral, and interior views of allotype, UMMP No. 27776, a male right valve. *4–5*, lateral and interior views of topotype, UMMP No., 27777, a female left valve. *6*, lateral view of topotype, UMMP No. 27778, a male right valve. (p. 765)

7–14—Abditoloculina insolita Kesling, n. sp. *7–9*, lateral, ventral, and interior views of allotype UMMP No. 27779, a male right valve. *10–11*, lateral and ventral views of paratype, UMMP No. 27780, a female left valve. *12–14*, lateral, ventral, and interior views of holotype, UMMP No. 27781, a female left valve with broken spurs. (p. 767)

15–19—Ctenobolbina megalia Kesling & Tabor, n. sp. *15–16*, right lateral and ventral views of allotype, UMMP No. 27782, a complete male carapace. *17–19*, dorsal, right lateral, and ventral views of holotype, UMMP No. 27783, a complete female carapace. (p. 761)

20–23—Winchellatia teleutaea Kesling & Tabor, n. sp. *20–21*, lateral and ventral views of allotype, UMMP No. 27784, a male right valve. *22–23*, lateral and ventral views of holotype, UMMP No. 27785, a female left valve. (p. 762)

ventral lobes, sloping gently to dorsal and posterior borders. Ventral lobe gently arched, confluent with anterior and front posterior lobes. Median sulcus deep, extending from dorsal border to middle of valve, curved anteroventrally in its ventral part. A very faint depression in the posterodorsal part of the anterior lobe, similar in position to an anterior sulcus, but incompletely setting off a median node.

Anterior cardinal angle about 120°; posterior cardinal angle about 115°.

A long, narrow frill from the anterior corner to the posteroventral part of each valve, slightly thicker in its posterior end. In a complete carapace, the two frills nearly parallel as seen in ventral view. Closely-spaced small papillae on a low marginal ridge extending from anterior corner to posteroventral part of free edge of each valve. Larger papillae on posterior border of each valve, not marginal, aligned with middle of channel between frill and marginal ridge. Lateral surface ornamented with papillae of two sizes; smaller papillae closely spaced, larger papillae scattered over entire lateral surface. Frill very finely granulose to smooth. Channel between frill and marginal ridge smooth or very finely granulose.

Description of female.—General lobation and surface ornamentation same as those of the male. Front posterior lobe larger than that of male. Frill slightly wider in anteroventral part. As seen in ventral view of complete carapace, frills farthest apart below the median sulci and closest together in anteroventral part of carapace. Entire carapace wider than that of the male. Channel between frill and marginal ridge of each valve with the same ornamentation as that of the lateral surface.

Dimensions of holotype, a complete carapace: length 1.13 mm., height 0.62 mm., and width 0.57 mm.

Remarks.—The specimens have been compared with topotype specimens of the closely related *Ctenobolbina papillosa* Ulrich (1891, p. 186, pl. 15, figs. 8a–c). They differ from those specimens in having the two sizes of papillae more nearly the same, fewer large papillae, narrower frills, more elongate carapaces, and no distinct posterior sulci.

Types.—Holotype, a female carapace, No. 27783. Allotype, a male carapace, No. 27782.

Genus WINCHELLATIA Kay 1940
WINCHELLATIA TELEUTAEA Kesling & Tabor, n. sp.
Plate 111, figures 20–23

Description of male.—Valves subpyriform in lateral view. Dorsal border straight, anterior border subround, ventral and posteroventral borders gently curved, and posterior border acutely subround. Anterior lobe gently arched, confluent with median and ventral lobes; front posterior lobe large, about one-fourth the length of the valve, inflated, extending slightly above hinge line, and separated from ventral lobe by a broad, very shallow depression; rear posterior lobe gently arched, sloping to dorsal and posterior borders. Ventral lobe wide, very gently arched, confluent with anterior lobe, and terminating posteriorly in a prominent posteroventral projection of the valve.

Anterior and posterior cardinal angles about 135°.

A small velate ridge runs from the anterior corner of the valve to the tip of the posteroventral projection. As seen in ventral view, this ridge curving sharply outward onto the projection and there recurving to its tip. Ventral surface of valve flat. A small marginal ridge along the free edge. Surface very finely granulose, nearly smooth.

Description of female.—General lobation and surface ornamentation same as those of the male, The velate structure, however, a frill instead of a ridge. Frill, as seen in ventral view, with same configuration as that of the male's velate ridge. Smooth channel between frill and marginal ridge, deepest in anteroventral part.

Dimensions of holotype, a female right valve: length 1.40 mm., height 0.87 mm., and width 0.43 mm.

Remarks.—This is the first description of a Devonian species of this genus. Kay (1940, pp. 253–255) described four species from the Decorah formation, Middle Ordovician, of the upper Mississippi valley. The lobation and the character of the dimorphism of this Devonian species are very similar to those described by Kay for the Ordovician species.

LITERATURE CITED

KAY, G. M., 1940, Ordovician Mohawkian Ostracoda: Lower Trenton Decorah fauna. Jour. Paleontology, vol. 14, pp. 234–269, pls. 29–34.

ULRICH, E. O., 1891, New and little known American Paleozoic Ostracoda: Jour. Cincinnati Soc. Nat. Hist., vol. 13, pp. 173–211, pls. 1–8.

MANUSCRIPT RECEIVED JULY 9, 1951

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 764–771, 1 TEXT FIG., SEPTEMBER 1952

DIMORPHISM IN DEVONIAN HOLLINID OSTRACODS OF NORTH AMERICA

ROBERT V. KESLING
Museum of Paleontology, University of Michigan, Ann Arbor

ABSTRACT—The hollinid ostracods from the Devonian of North America are known to be dimorphic in many species. Dimorphic structures of eleven genera (one new) are described in this paper. The recognition of dimorphism is important in the taxonomy of the Devonian Hollinidae.

INTRODUCTION

IN DEVONIAN hollinid ostracods, dimorphism exists in so many genera and species that an understanding of its nature and forms is necessary for taxonomic work.

Many workers on the Hollinidae have detected dimorphism in some genera, and have properly included dimorphic forms in the same species. Kellett (1929, pp. 196–217) investigated some dimorphic species of *Hollinella* from the Carboniferous, and established the nature of dimorphism in that genus. Warthin (1934, p. 209) recognized the unusual dimorphism in *Ctenoloculina cicatricosa* (Warthin), and (1937, Card 54) suggested that *Parabolbina limbata* Swartz and *P. ventrispinosa* Swartz were dimorphs of one species. Swartz (1936, p. 552) suggested that *Hollina armata* (Ulrich) and *H. cavimarginata* (Ulrich) were dimorphs of one species. Stewart (1936, p. 745) recognized the dimorphic forms of *Tetrasacculus* when she described that genus. Stewart and Hendrix (1945, p. 103) described *Bisacculus* as dimorphic. Kesling and McMillan (1951, pp. 65, 67–68) defined *Falsipollex* and *Subligaculum* as dimorphic. Other workers on Hollinidae have also called attention to the dimorphic forms of some species.

In contrast to the Beyrichiidae, which have large anteroventral lobes forming internal pouches in the female dimorph, the Hollinidae have dimorphism primarily in the form of unusual velate structures, and have no internal pouches. Although some of the older genera of the Hollinidae have not been found to be dimorphic, the Devonian genera of the family have many dimorphic species, and additional work may prove that all Devonian species are dimorphic. The differences between the two dimorphs in some species are very small, and I have found that numerous specimens and careful observation are sometimes necessary to determine the nature of the dimorphism.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA
Class CRUSTACEA
Order OSTRACODA
Superfamily BEYRICHIACEA
Family HOLLINIDAE Swartz 1936

Ostracods of this family have straight hinge lines and velate structures. Devonian genera develop unusual velate structures, which show dimorphism in many species. The lobation in some genera consists of an anterior lobe, a small nodelike median lobe, a large front posterior lobe (bulbous and extending above the hinge line in some genera), and a low, gently arched rear posterior lobe. The lobation of other genera, however, differs in having the anterior and median lobes confluent, a reduced front posterior lobe, and/or the two posterior lobes confluent. All genera have a well-developed median sulcus, and some also have anterior and posterior sulci.

The Devonian hollinid genera described below are discussed by lobation, dimorphic structures of the males, and dimorphic structures of the females.

Genus HOLLINA Ulrich & Bassler

Genotype.—Ctenobolbina insolens Ulrich, 1900, p. 182, pl. 8, figures 10, 11, by subsequent designation of Ulrich and Bassler, 1908, p. 315.

Lobation.—Valves subelliptical, subquadrate, or subpyriform in lateral view. Anterior lobe well developed, reaching the dorsal

border; median lobe small, not reaching the dorsal border; front posterior lobe bulblike or knoblike, located in the dorsal part of the valve, and extending above the hinge line; the rear posterior lobe developed in some species as a node. Ventral part of valves with various lobes or nodes. Median sulcus extending from the dorsal border to the middle of the valve, deeper and broader than the other sulci. Anterior sulcus well defined; posterior sulcus well defined in the genotype.

Males.—A discussion of dimorphism in the Hollinidae should begin with the genotype of the type genus of the family. In an examination of a sample from the bryozoan bed of the Jeffersonville limestone at the Falls of the Ohio, I found a topotype female of *Hollina insolens* (Ulrich) (UMMP No. 27777) (Plate 111, figs. 4–5) and three males of the same species (UMMP Nos. 27776, 27778, and 27786). No. 27776 (Plate 111, figs. 1–3) is designated the allotype of *Hollina insolens* (Ulrich). This male specimen is a well-preserved right valve having the same lobation in the dorsal part of the valve as that of the female specimens. In the ventral part of the valve there is no frill, but the valve is extended into two ventral projections. The anterior projection is dorsally separated from the anterior lobe by a shallow saddle, tapers slightly, and terminates in a rounded, subconical tip slightly below the anteroventral part of the free edge. The posterior projection is an extension of a prominent slanting lobe which is separated from the bulblike front posterior lobe by a shallow saddle. The termination of this projection is blunt, extending to the ventral border, subround in lateral view, and elliptical in ventral view. The similarities of the male to the female in size, lobation, and surface ornamentation identify it as a dimorph of *Hollina insolens* (Ulrich).

In dimorphic Hamilton species having this general lobation in the dorsal part of the valve, there are no nodes or lobes in the ventral part of the valve and the ventral projections of the male are solid spurs instead of lobations of the valve. They are included in the genus *Falsipollex* Kesling and McMillan.

Females.—The frill of the genotype is strongly curved inward. The two frills in a complete carapace nearly meet at their distal ends. The genus should be restricted to those species having a simple incurved frill in the female, and those species with loculi and this general lobation in the female should be placed in *Abditoloculina* Kesling, n. gen.

Genus FALSIPOLLEX Kesling & McMillan

Genotype.—By original designation, *Falsipollex altituberculatus* Kesling & McMillan, 1951, pp. 68–69, pl. 3, figures 1–3.

Lobation.—Valves subpyriform to subelliptical in lateral view. Anterior lobe distinct, in some species confluent ventrally with the rest of the valve, similar to the corresponding lobe of *Hollinella;* median lobe small, nodelike, located below the dorsal border; front posterior lobe large, bulblike, extending above the hinge line; rear posterior lobe small, low in some species, nodelike in others. Ventral part of valve slightly lobate in some species, nearly flat in others. Median sulcus distinct, deep, from the dorsal border to middle of the valve. Surface of valve in known species papillose.

Males.—Each valve has two spinelike velate spurs, a shorter one on the anteroventral part of the valve and a longer one on the posteroventral part.

Females.—A wide frill on each valve extends from the anterior corner or near that corner to the posteroventral part of the valve. This frill is somewhat incurved, particularly in the anteroventral part. In its anterodorsal part, the frill is partially confluent with the anterior lobe in some species.

ABDITOLOCULINA Kesling, n. gen.

Genotype.—Abditoloculina insolita Kesling, n. sp.

Lobation.—Valves subelliptical to subpyriform in lateral view. Anterior lobe well defined; median lobe small, below dorsal border; front posterior lobe knoblike or bulblike, located in dorsal part of valve; rear posterior lobe low, evenly arched, in some species confluent with ventral part of valve. Ventral part of valve flat or developed as a low, elongate lobe.

Males.—Velate structures present as two

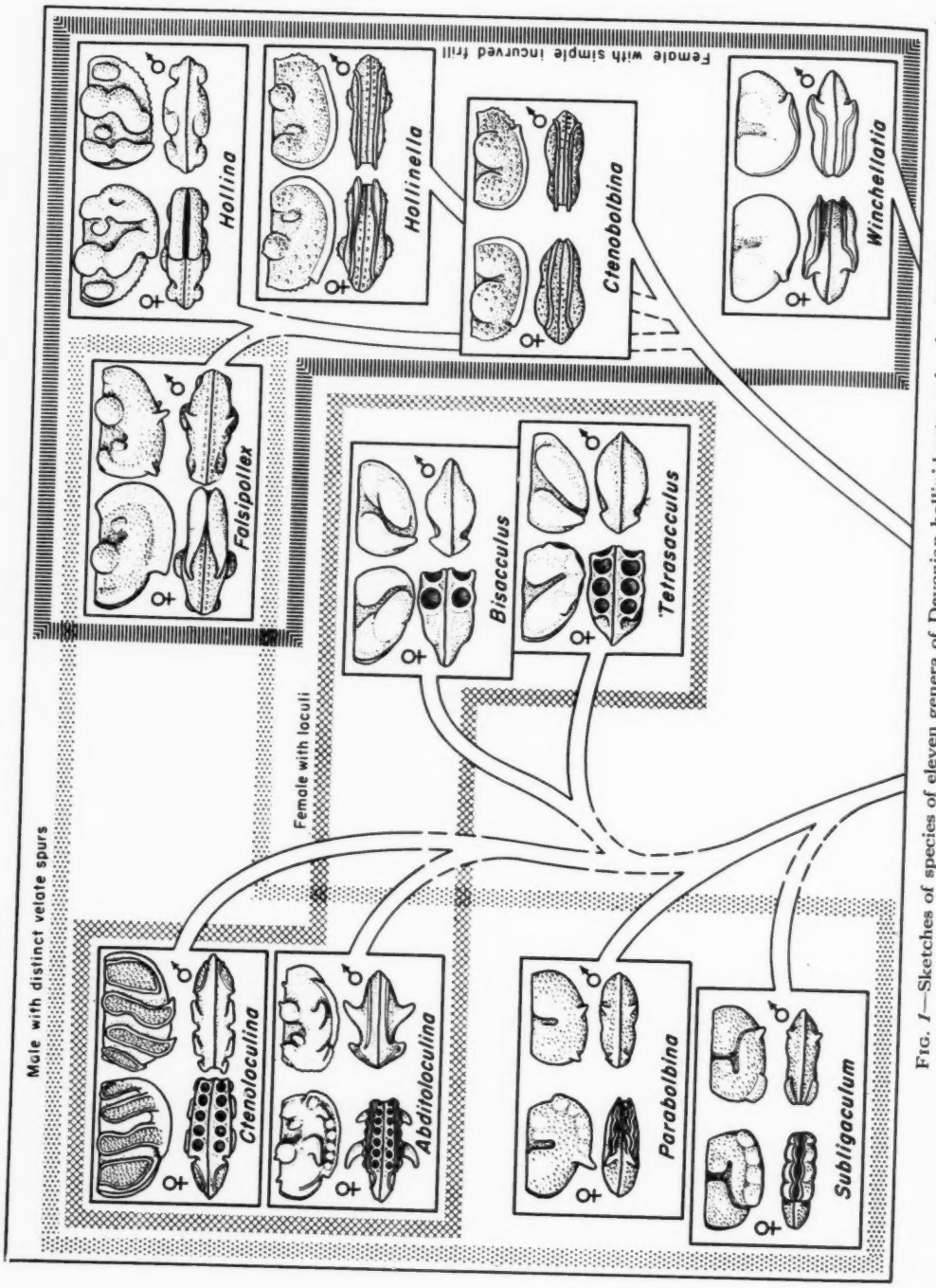


FIG. 1—Sketches of species of eleven genera of Devonian hollinid ostracods, showing the dimorphism and suggested relationships.

prominent spurs in the ventral part of each valve. In the genotype, there is a sharp velate ridge extending from the anterior part of the valve around the anteroventral border of the anterior spur; another velate ridge, nearly confluent with the first at its anterior end, terminates in the posteroventral part of the valve.

Females.—A well-developed frill in the anterior and ventral parts of each valve has several loculi. In the known species, there are also two spurs, the anterior one on the anteroventral part of the frill and the posterior one originating above the posterior part of the frill. The loculi are located between the wide, slightly incurved frill and a low marginal ridge, with their openings directed inward as well as downward.

Remarks.—*Abditoloculina armata* (Ulrich) is a male and *Abditoloculina cavimarginata* (Ulrich) is a female. I have not examined enough specimens to determine if they are dimorphs of one species, as suggested by Swartz (1936, p. 552, pl. 80, figs. 3b–c). However, specimens of *A. armata* (Ulrich) have the velate ridges in the same positions as those of the male of the genotype of *Abditoloculina*.

The loculi and frill of the female and the spurs of the male resemble the corresponding velate structures in *Ctenoloculina* Bassler, but the lobation of this genus is more like that of *Hollinella* Coryell, and quite different from the reticulate, flat, long, transverse lobes of *Ctenoloculina*.

ABDITOLOCULINA INSOLITA Kesling, n. sp.
Plate 111, figures 7–14

Description of male.—Valve small, subpyriform to subelliptical in lateral view. Hinge line straight; anterior free border subround; ventral free border gently curved; posterior border curved. Anterior and ventral parts of free border partly hidden by velate structures. Anterior lobe nodelike, with a short, subconical spine in its posterodorsal part; median lobe small, elongate vertically, located slightly below dorsal border and near the anterior lobe; front posterior lobe knoblike, extending above hinge line, with a short, subconical spine in its posterodorsal part; rear posterior lobe low, confluent with the ventral part of the valve, with a short spine on its dorsal border.

Two prominent posteriorly-directed spinelike spurs in the ventral part of valve, with hollow bases. Anterior spur about two-thirds the length of the posterior spur, located below the anterior lobe. Posterior spur located below the front posterior lobe, slightly above the position of the anterior spur. Delicate, sharp velate ridge from anterior part of valve to the ventral part of spur, there joining an unusual small cylindrical projection; another delicate velate ridge parallel to the free edge, nearly confluent with the first velate ridge at its anterior end and terminating in the posterior part of valve. Small, low marginal ridge around free edge.

Anterior and posterior cardinal angles about 105° each.

Surface nearly smooth, somewhat reticulate with numerous very shallow dents. Interior of valve with five prominent depressions marking the positions of the anterior, median, and front posterior lobes and the two spurs.

Description of female.—General size, lobation, outline, and surface ornamentation the same as those of male. Complex frill from anterior to posteroventral part of valve, confluent with a delicate velate ridge extending to the posterior part of the valve. As seen in lateral view, seven nodose structures on the frill, marking the locations of the loculi inside; the second of these structures partly obscured by the anterior spur. As seen in ventral view, frill with two parallel rimlike edges and seven loculi. Loculi of equal size; the opening of each loculus with a distinct rim. Two long spurs, the anterior one slightly shorter with its base outside the second loculus of the frill, and the posterior one with its base above the frill, dorsal to the fifth and sixth loculi.

Remarks.—The lobation of the female exactly duplicates that of the male of this species. The female also has the short spines on the anterior, front posterior, and rear posterior lobes.

The exotic, long, curved, spinelike spurs in both male and female dimorphs separate this species from *Abditoloculina cavimarginata* (Ulrich) and from *Abditoloculina armata* (Ulrich).

Occurrence.—Bryozoan beds of the Jeffersonville limestone at the Falls of the Ohio. Specimens are from a sample given to the

dimorphism and suggested relationships.

Museum of Paleontology of the University of Michigan by Dr. R. S. Bassler.

Types.—Holotype, a left female valve, No. 27781. Allotype, a right male valve, No. 27779. Paratype, another left female valve, No. 27780. All types in the Museum of Paleontology of the University of Michigan.

Genus CTENOLOCULINA Bassler

Genotype.—*Tetradella cicatricosa* Warthin, 1934, p. 209, pl. 1, figures 4–6, by original designation of Bassler, 1941, pp. 22–23.

Lobation.—Valves subelliptical in lateral view. Left valve slightly larger and overlapping right valve around the free edge. Four lobes unusually well defined, with flat surfaces, reticulate, each with a distinct smooth rim. Anterior lobe from dorsal border to anteroventral border, median lobe from dorsal border to ventral border or to junction with the frill, slanting, with nearly parallel sides; front posterior lobe large, from dorsal border to ventral border or to its junction with the frill, constricted near the middle; rear posterior lobe subtriangular, its posterior border parallel to the posterior border of the valve, its dorsal border parallel to the hinge line, and its anterior border straight and slanting. Sulci smooth, with rounded bottoms.

Males.—Flat spurs project from the anterior three lobes. The anterior spur is very short and pointed; the middle spur is long, extending below the free edge, its tip curved backward; the rear spur is large, relatively flat on its ventral edge but with a sharp point directed backward. These dimorphic characters were recognized first by Warthin (1934, p. 209) and then by Bassler (1941, pp. 22–23).

Females.—A curved frill extends from the anterior to the posteroventral part of each valve. There are several loculi between this frill and the marginal ridge. In a complete carapace, the openings of the loculi of the two valves form a nearly flat surface between the distal edges of the two frills.

Genus HOLLINELLA Coryell

Genotype.—By original designation, *Hollinella dentata* Coryell, 1928, p. 378, pl. 51, figure 1.

Lobation.—Valves subelliptical to subpyriform in lateral view. Anterior lobe well defined in most species; median lobe small, nodelike, in some species partially confluent with the front anterior lobe; front posterior lobe large, bulblike, extending above the hinge line; rear posterior lobe low and gently rounded in many species, but nodelike and sharply set off in others. An elongate ventral lobe present in some species. Median sulcus deep and extending from the dorsal border to about the middle of the valve.

Males.—Frills of the males in the Devonian species of this genus are curved outward. Some species of the Hamilton group of Michigan have the curvature of the frill in the males strongly emphasized, and the width of the carapace, particularly through the prominent bulblike lobes, less than that of the females.

Females.—Females have the frills curved inward. In Devonian species, this curvature is strongest in the anteroventral part of the frill. No Devonian species have the two frills incurved to meet at their distal edges, as have some of the Carboniferous species. No Devonian species have pronounced dimorphism, and it is very difficult to separate the two dimorphs of some species.

Genus CTENOBOLBINA Ulrich

Genotype.—*Beyrichia ciliata* Emmons, 1855, p. 219, text figure 74c, by subsequent designation of Ulrich, 1890, p. 108, pl. 7, figures 1a, b.

Lobation.—Valves subelliptical to subquadrate in lateral view. Anterior lobe slightly inflated, reaching the dorsal border, nearly confluent with median lobe; front posterior lobe low, in many species confluent with the ventral part of the valve. A slight development of a ventral lobe in some species, usually forming a ventral connection between the anterior and the front posterior lobes. Median sulcus deep, sharply defined.

Males.—Although dimorphism is not commonly recognized in this genus, *Ctenobolbina megalia* Kesling and Tabor (pl. 111, figs. 15–19) has definite differences in the two dimorphs. The male (pl. 111, figs. 15–16) has a narrower carapace than that of the female, and its frill is directed slightly outward. The two frills are parallel as seen in ventral view, and do not have an anteroventral constriction.

Females.—The specimen shown in Plate 111, figures 17–19 has the same lobation and surface ornamentation as those of the male. It differs from the male in having greater thickness, the frills curved inward in the anteroventral part, and ornamentation like that of the lateral surface in the channel between the frill and the free edge of each valve. The inward curvature of the frills in the anteroventral parts is very similar to that of *Hollinella*. It is interesting that the dimorph designated as the female has both the greater thickness and the inwardly-curved frill. With these criteria, I was able to separate over 100 specimens of *Ctenobolbina megalia* Kesling and Tabor from one locality into two groups, and found remarkable constancy within each group.

Genus TETRASACCULUS Stewart

Genotype.—By original designation, *Tetrasacculus bilobus* Stewart, 1936, p. 745, pl. 100, figures 8–11.

Lobation.—Carapace subpyriform in lateral view. Carapace broad, the width nearly equal to the height. Free border with anterior part rounded and posteroventral part sloping with a gentle curve. Anterior lobe nearly triangular, bounded by the anterior border of the valve, the dorsal border, and the long, transverse median sulcus; posterior lobe very elongate, with its axis forming an acute angle (about 45° in many species) with the dorsal border.

Males.—The dimorphism of this genus was recognized by Stewart at the time she described the genotype. Males have little or no velate structures. The ventral end of the anterior lobe in some species extends downward as a conical tip.

Females.—In contrast to the males of this genus, which never have prominent velate structures, the females have frills which are larger in proportion to the size of their carapaces than those of any other genus. The frill extends straight down from the side of each valve, and has loculi. Although these loculi are few in number, they are very large. Each loculus has a distinct rim around its opening. The number of loculi varies in female dimorphs having this lobation; some from the Middle Devonian Traverse group of Michigan have three complete loculi and a posterior incomplete loculus which lacks a posterior wall. These species are intermediate in form between the genotype of *Tetrasacculus* Stewart, with four loculi in each valve, and the genotype of *Bisacculus* Stewart and Hendrix, with two loculi in each valve.

Genus BISACCULUS Stewart & Hendrix

Genotype.—By original designation, *Bisacculus bilobus* Stewart & Hendrix, 1945, p. 103, pl. 11, figures 16–18.

Lobation.—Same as that of *Tetrasacculus* Stewart.

Males.—Males of the genotype, as described by Stewart and Hendrix, with blunt ventral spine on the anterior lobe. Males of this genus are apparently very similar to those of *Tetrasacculus*.

Females.—A broad frill extends downward from the side of each valve and has two large loculi. The openings of these loculi have rims. As noted above, some "Tetrasacculus" species have the fourth (posterior) loculus incomplete; *Bisacculus* may be only a group of species of *Tetrasacculus* with fewer loculi.

Genus PARABOLBINA Swartz

Genotype.—*Ctenobolbina granosa* Ulrich, 1900, p. 183, pl. 8, figure 12, by subsequent designation of Swartz, 1936, p. 570.

Lobation.—Valves subelliptical in lateral view. Anterior lobe indistinctly subdivided by a very shallow sulcus; rear anterior lobe not developed and confluent with front anterior lobe in some species, front part of posterior lobe larger than other lobes but not extending above the hinge line. Median sulcus deep and well defined, from dorsal border nearly to the middle of the valve.

Males.—Two short spurs characterize males of this genus. One is anteroventral and the other is posteroventral. In the Genshaw formation, Middle Devonian Traverse group of Michigan, there are several males of a species of *Parabolbina*, but no females have been found. The dimorphism in this genus should be studied in more detail.

Females.—A scalloped frill extends from the anterior corner to the posteroventral part of the valve. The number of these scallops appears to be a specific character.

In a complete carapace, the two frills nearly meet at places where there are indentations of the scallops.

Genus SUBLIGACULUM Kesling & McMillan

Genotype.—By original designation, *Subligaculum scrobiculatum* Kesling & McMillan, 1951, pp. 65–66, pl. 2, figures 1–4; pl. 7, figures 1–8.

Lobation.—Similar to that of *Parabolbina* except for the median sulcus, which has anterior and posterior extensions from its ventral end.

Males.—The velate structures of the male are distinctive and differ from those of other hollinid ostracods. There is a posteroventral short spur and an anteroventral short frill. These structures are consistent for several Hamilton species, some of them undescribed.

Females.—The females have a scalloped frill like that of *Parabolbina*, but incurved somewhat more. Females and males are present in about equal numbers in the Hamilton formations, and although the females are very similar to those of *Parabolbina*, except in details of lobation, the males are very distinctive.

Genus WINCHELLATIA Kay

Genotype.—By original designation, *Winchellatia longispina* Kay, 1940, p. 253; pl. 32, figures 1–5.

Lobation.—Valves subpyriform to subelliptical. Anterior lobe undivided or with shallow groove in the posterior part; front posterior lobe large, but tangent to hinge line or extending only a little above it; rear posterior lobe confluent with ventral part of valve.

Males.—The dimorphism and lobation of *Winchellatia teleutaea* Kesling and Tabor (pl. 111, figs. 20–23) is very close to that of the genotype described by Kay from the Ordovician. This is the first species of this interesting genus from the Devonian to be described. The male has only a narrow, low velate ridge, and no channel between the velate ridge and the low marginal ridge.

Females.—Females have nearly the same lobation as the males, and are difficult to distinguish in lateral view. In ventral or end views, however, the frill can be seen clearly, separated from the marginal ridge by a deep, smooth channel.

RELATIONSHIPS OF DEVONIAN DIMORPHIC HOLLINID OSTRACODS

Of the genera discussed above, three were already present in the Ordovician period—*Parabolbina*, *Ctenobolbina*, and *Winchellatia*. As far as is known, these three genera became extinct by the end of the Middle Devonian.

The other eight genera have no species reported from formations older than the Devonian. *Tetrasacculus* and *Hollinella* extend into the Mississippian and Permian respectively. *Subligaculum*, *Abditoloculina*, *Ctenoloculina*, *Falsipollex*, *Bisacculus*, and *Hollina* are reported only from the Devonian.

The ranges of these genera, although they may be extended somewhat by future paleontological work, show that the Devonian was a time of rapid evolution for the Hollinidae, when the old generic characters died out and many new ones began.

Winchellatia does not appear to have changed greatly from its origin to its disappearance. The Devonian species are remarkably similar to those of the Middle Ordovician.

As indicated in figure 1, *Subligaculum*, *Abditoloculina*, *Ctenoloculina*, *Tetrasacculus*, and *Bisacculus*, all with rather complex frills in the female dimorphs, are presumed to have originated from *Parabolbina*. *Abditoloculina*, *Ctenoloculina*, *Tetrasacculus*, and *Bisacculus* females have loculi in their frills. *Abditoloculina* and *Ctenoloculina* are distinctly quadrilobate, and seem to be more closely related to each other than to *Tetrasacculus* and *Bisacculus*, which are nearly bilobate. *Subligaculum* females have a scalloped frill like that of *Parabolbina*. No males of *Parabolbina* or its descendants have a well developed frill. *Tetrasacculus* and *Bisacculus* males have scarcely any velate structures. *Parabolbina*, *Abditoloculina*, and *Ctenoloculina* males have two spinelike spurs on each valve, and *Subligaculum* males have a spur and a short anteroventral frill on each valve.

Hollinella, *Hollina*, and *Falsipollex*, all with simple incurved frills in the female dimorph, are presumed to have originated

from *Ctenobolbina* (see fig. 1). These three genera, which appeared in the Devonian, have remarkably similar lobation, particularly in the bulblike shape of the front posterior lobe. Furthermore, most Devonian species of *Ctenobolbina*, *Hollinella*, *Hollina*, and *Falsipollex* have unusual surface ornamentation, such as short blunt spines and papillae of various sizes. In the *Ctenobolbina* descendants the males show a progressive decrease in the size of the velate structures; *Hollinella* males have a complete frill curved outward on each valve, *Hollina* males have two lobate ventral projections on each valve, and *Falsipollex* males have variously-shaped solid spurs. The spurs of male *Falsipollex altituberculatus* Kesling and McMillan (1951, p. 68, pl. 3, figs. 1–3), from the Bell shale, are large and their lateral surfaces are confluent with the ventral part of the valve; but the spurs of *Falsipollex* sp. from younger formations of the Traverse group of Michigan are smaller, more spinelike, and distinctly set off from the rest of the valve.

The manner in which velate structures were formed reveals certain differences of the *Ctenobolbina* lineage from the *Parabolbina* lineage. Because the base of velate structures is completely fused with the rest of the valve, as can be seen in thin sections of ostracod valves, all of the calcium carbonate in the distal part of a spur or frill must have been formed before the remainder of the valve. Velate structures resulted, therefore, when the hypodermal cells of a limited area were stimulated to secrete calcium carbonate immediately after the final molting of the carapace, while the other hypodermal cells remained inactive. If the hypodermal cells receiving this initial stimulus were in two small areas, spurs were formed; if the cells were in a long, narrow area, a frill was formed. The cells making the frills of females of the *Ctenobolbina* lineage were in a narrow band lying almost in one plane. In contrast, those making the scalloped frills of *Subligaculum* and *Parabolbina* females were in short, connected arcs, and those secreting the frills with loculi in *Ctenoloculina*, *Abditoloculina*, *Tetrasacculus*, and *Bisacculus* females were arranged in small contiguous circles. The formation of the frills was more complex than that of most other structures in the hollinid ostracods, and the form of the frills should, I believe, be carefully considered in the taxonomy of this family.

MANUSCRIPT RECEIVED JULY 9, 1951

LITERATURE CITED

BASSLER, R. S., 1941, Ostracoda from the Devonian (Onondaga) chert of west Tennessee: Jour. Washington Acad. Sci., vol. 31, pp. 21–27.

CORYELL, H. N., 1928, Some new Pennsylvanian Ostracoda: Jour. Paleontology, vol. 2, pp. 377–381, pl. 51.

EMMONS, E., 1855, American geology, containing a statement of the principles of the science with full illustrations of the characteristic American fossils, vol. 1, pt. 2, pp. 218–220, figs. 7,4 a–c, and 75, a–d, atlas. Albany.

KAY, G. M., 1940, Ordovician Mohawkian Ostracoda: Lower Trenton Decorah fauna: Jour. Paleontology, vol. 14, pp. 234–269, pls. 29–34.

KELLETT, B., 1929, The ostracode genus *Hollinella*, expansion of the genus and description of some Carboniferous species: Jour. Paleontology, vol. 3, pp. 196–217, pls. 25–26.

KESLING, R. V. and MCMILLAN, G. W., 1951, Ostracods of the family Hollinidae from the Bell shade: Contrib. Mus. Paleontol., Univ. of Michigan, vol. 9, no. 2, pp. 45–81, pls. 1–5.

STEWART, G. A., 1936, Ostracodes of the Silica shale, Middle Devonian, of Ohio: Jour. Paleontology, vol. 10, pp. 739–763, pls. 100–102.

STEWART, G. A. and HENDRIX, W. E., 1945, Ostracoda of the Olentangy shale, Franklin and Delaware counties, Ohio: Jour. Paleontology, vol. 19, pp. 96–115, pls. 11, 12.

SWARTZ, F. M., 1936, Revision of the Primitiidae and Beyrichiidae, with new Ostracoda from the Lower Devonian of Pennsylvania: Jour. Paleontology, vol. 10, pp. 541–586, pls. 78–89.

ULRICH, E. O., 1890, New and little known American Paleozoic Ostracoda: Jour. Cincinnati Soc. Nat. Hist., vol. 13, pp. 104–137.

——, 1900, New American Paleozoic Ostracoda. No. 1, *Ctenobolbina* and *Kirkbya:* Jour. Cincinnati Soc. Nat. Hist., vol. 19, pp. 179–186, pl. 8.

——, and BASSLER, R. S., 1908, New American Paleozoic Ostracoda. Preliminary revision of the Beyrichiidae, with descriptions of new genera: U. S. Nat. Mus. Proc., vol. 35, pp. 277–340, figs. 1–61, pls. 37–44.

WARTHIN, A. S., JR., 1934, Common Ostracoda of the Traverse group: Contrib. Mus. Paleontol., Univ. of Michigan, vol. 4, pp. 205–226, pl. 1.

——, 1937, Type invertebrate fossils of North America (Devonian). Beyrichiacea. Philadelphia: Wagner Free Inst. of Sci.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 772–780, 1 TEXT FIG., SEPTEMBER 1952

DOUBLING IN SIZE OF OSTRACOD CARAPACES IN EACH MOLT STAGE

ROBERT V. KESLING
Museum of Paleontology, University of Michigan, Ann Arbor

ABSTRACT—Przibram believed that crustaceans grow to twice their former size during each molt stage. A study of some Paleozoic ostracods indicates that the carapace for each instar of a species is twice the size of that of the preceding instar, although its shape may change. Various methods of measuring the volume of an ostracod carapace are discussed.

INTRODUCTION

PRZIBRAM (1931, p. 26) believed that crustaceans increase their weight to twice its former value during each molt stage. This concept can be formulated as

$$\frac{l_{(n+1)}\times h_{(n+1)}\times w_{(n+1)}}{l_n\times h_n\times w_n}=2,$$

where l is the mean length of the carapace, h is the mean height of the carapace, w is the mean width of the carapace, n is an immature instar, and $n+1$ is the following instar. If the shape of the carapace does not change from instar n to instar $n+1$, then the formula can be written as

$$\frac{L_{(n+1)}\times H_{(n+1)}\times W_{(n+1)}}{L_n\times H_n\times W_n}=2,$$

where L, H, and W are the maximum values of length, height, and width respectively. Furthermore, if the shape of the carapace does not change from one instar to the next, then

$$\frac{L_{(n+1)}}{L_n}=\frac{H_{(n+1)}}{H_n}=\frac{W_{(n+1)}}{W_n}$$

and the formula becomes

$$\left[\frac{L_{(n+1)}}{L_n}\right]^3=2,$$

Hence,

$$L_{(n+1)}=\sqrt[3]{2}\ L_n=1.2592\ L_n.$$

Przibram used the figure 1.26, stating that a dimension increases its value 1.26 times from one instar to the next.

Sohn (1950, p. 451) compared the lengths of carapaces in instars of several species of ostracods. The increase in length from one instar to the next was not exactly 1.26 for any species which he investigated; for several species, the increase differed greatly from this figure. For this reason, Sohn believed Przibram's formula was of little use in ostracod studies.

However, the shape of the carapace does change from one instar to the next, and the increase in size or volume may not correspond to the increase in one dimension. This paper is an examination of Przibram's basic concept, that the mass of an arthropod doubles during each molting, as it applies to ostracod carapaces. The volumes of enclosing rectangular parallelepipeds are compared for carapaces, valves, and internal molds in instars of several species.

Four methods of measuring volume are described, and the errors possible in each method are discussed.

A more critical evaluation of Przibram's idea could be made by using methods of measuring the volume of valves and carapaces which are more accurate than the method used in this study (Method D described below).

INCREASE IN SIZE OF CARAPACES, VALVES, AND INTERNAL MOLDS IN INSTARS OF SEVERAL SPECIES

Very few authors have included measurements of all specimens used in their descriptions. Hessland (1949) included the important measurements of many specimens in his excellent work on the Lower Ordovician ostracods of central Sweden. His figures have been used extensively in this study. The writer's measurements of *Ctenoloculina cicatricosa* (Warthin) from the Norway Point formation have also been included.

In Tables I to VI the volume increase for each molt stage is computed from the product of the greatest length, height, and width of carapaces, valves, and internal molds in each instar. This factor can be computed only for the interval between consecutive instars of one species, and its significance increases with the number of specimens in each of the instars.

Although the proportions of one instar may differ somewhat from that of the preceding instar, the volume increases for the molt stages between the instars are remarkably close to two. There are forty-one pairs of consecutive instars in which each instar is represented by two or more specimens; the mean volume increase for the molt stages represented is 2.010, the standard deviation is 0.22, and the coefficient of variation is 11%. There are twenty-two pairs of consecutive instars in which each instar is represented by three or more specimens; the mean volume increase in this group is 1.986, the standard deviation of volume increase is 0.191, and the coefficient of variation is 9.6%. Furthermore, in this group the average departure from the theoretical factor of 2 is only 0.153. This is an average departure of only 7.7% for the product of length, height, and width, or only 1.97% for each dimension. An error of less than 2% is very close to the accuracy used in measuring the specimens. There are two pairs of consecutive instars in which each instar is represented by twenty-five or more specimens; the volume increases for these molt stages are 2.05 and 1.97.

These figures support Przibram's proposal that crustaceans double their size during each molt stage, and indicate that they exactly double it.

A COMPARISON OF THE GROWTH CONCEPTS OF PRZIBRAM, BROOKS, AND HUXLEY

Three concepts of arthropod growth have been described by Przibram, Brooks, and Huxley. It can be demonstrated that these concepts are interrelated, and that none of them contradicts or excludes the conditions of the other two.

Brooks applied his idea to another group of crustaceans, the Stomatopoda, but Fowler (1909, p. 224) adopted the same idea for ostracods and termed it Brooks' Law. Fowler proposed that each instar differs from the previous instar by increasing its length by a fixed percentage, and that this percentage remains constant for all instars of a species. He formulated this as

$$L_{(n+1)}=L_n(C+1),$$

where L_n is the greatest length of specimens in instar n, $L_{(n+1)}$ is the greatest length of specimens in instar $n+1$, and C is the constant percentage for the species. An examination of the measurements listed in Tables I to VI reveals that this relationship is also essentially true for other dimensions. Brooks' Law can be reworded, therefore, to read that each instar differs from the previous instar by increasing its dimensions by fixed percentages, and that these percentages remain constant for each dimension considered in the ontogeny of a species.

Comparison of the ideas of Brooks to those of Przibram shows that the fixed percentages of increase in length, height, and width are related and interdependent. The increases in height and width can be formulated as

$$H_{(n+1)}=H_n(C_2+1)$$

and

$$W_{(n+1)}=W_n(C_3+1),$$

where C_2 and C_3 are the fixed percentages for height and width respectively. If these formulas are used for substitutions in Przibram's formula, then

$$L_n(C+1)\times H_n(C_2+1)\times W_n(C_3+1) = 2\times L_n\times H_n\times W_n$$

or

$$(C+1)(C_2+1)(C_3+1)=2.$$

It is now apparent that if one dimension increases by a large fixed percentage in the ontogeny, then the other dimensions must increase by proportionately smaller fixed percentages.

Huxley (1924, p. 895; 1932, pp. 6–8) proposed a formula for comparison of relative growth rates. As adapted to dimensions of ostracod carapaces, this formula can be expressed

$$H=b'L^{k'} \quad \text{and} \quad W=b''L^{k''},$$

where b' and b'' are constants and k' and k'' are the constant differential growth ratios

TABLE—I. MEAN DIMENSIONS OF OSTRACOD CARAPACES AND VALVES IN VARIOUS INSTARS OF EIGHT SPECIES, AND THE VOLUME INCREASES COMPUTED FOR THE MOLT STAGES

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, p. 185	*Aparchites depressulus* Hessland Type *β*	Adult	4 valves	0.547	0.350	0.340	0.0651	
		8	2 valves	.45	.28	.27	.0340	1.92
		7	1 valve	.37	.23	.23	.0196	1.74
		6	1 valve	.26	.18	.17	.0080	2.45
Hessland, pp. 289–292	*Aulacopsis bifissurata* Hessland Types *a–d*	Adult	10 valves	.937	.560	.469	.2461	
		8	6 valves	.762	.488	.393	.1462	1.69
		7	3 valves	.597	.390	.297	.0692	2.11
		6	2 valves	.480	.315	.225	.0340	2.04
		5	—	—	—	—	—	4.25
		4	1 valve	.30	.19	.14	.0080	
Hessland, p. 379	*Bythocypris* sp. A (sine nomine)	Adult	2 valves	.755	.370	.410	.1145	
		8	3 valves	.623	.327	.327	.0666	1.72
Hessland, p. 378	*Bythocypris curvata* Hessland	Adult	1 valve	.78	.37	.42	.1212	
		8	4 valves	.700	.343	.315	.0756	1.60
		7	1 valve	.50	.27	.23	.0311	2.43
		6	1 valve	.44	.21	.20	.0185	1.68
Hessland, p. 375	*Bythocypris elongata* Hessland	Adult	1 carapace	.87	.42	.41	.1498	
		8	1 carapace	.75	.36	.33	.0891	1.68
		7	1 carapace	.60	.30	.28	.0502	1.77
Hessland, p. 368	*Bythocypris monocarinata* Hessland	Adult	1 carapace	1.19	0.79	0.70	0.6580	
		8	1 carapace	.93	.58	.57	.3075	2.14
Hessland, p. 373	*Bythocypris monoumbonata* Hessland Type *b*	Adult	2 carapaces	1.255	.770	.620	.5991	
		8	—	—	—	—	—	3.73
		7	1 carapace	.78	.49	.42	.1605	
Hessland, p. 371	*Bythocypris nonumbonata* Hessland Type *b*	Adult	1 carapace	1.08	.65	.63	.4422	
		8	—	—	—	—	—	4.48
		7	1 carapace	.65	.41	.37	.0986	

TABLE II.—MEAN DIMENSIONS OF OSTRACOD CARAPACES, VALVES, AND INTERNAL MOLDS IN VARIOUS INSTARS OF SEVEN SPECIES, AND THE VOLUME INCREASES COMPUTED FOR THE MOLT STAGES

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, p. 376	*Bythocypris obliquedorsata* Hessland	Adult	3 carapaces	.710	.380*	.317	.0855	
		8	1 carapace	.52	.29	.26	.0392	.218
Hessland, p. 197	*Ceratocypris longispina* Hessland Type *α*	Adult	2 valves	1.385	.900	.970	1.2091	2.17
		8	1 valve	1.08	.67	.77	.5572	2.33
		7	1 valve	.84	.50	.57	.2394	2.44
		6	1 valve	.63	.37	.42	.0979	
Hessland, p. 198	*Ceratocypris longispina* Hessland Type *β*	Adult	1 valve	1.35	.79	.79	.8425	2.31
		8	3 valves	.997	.607	.603	.3649	
		7	—	—	—	—	—	8.86
		6	—	—	—	—	—	
		5	1 valve	.49	.29	.29	.0412	

TABLE II—*Continued*

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, p. 180	*Conchoides* sp. *B* (sine nomine)	Adult	2 molds	0.730	0.440	0.380	0.1221	1.96
		8	3 molds	.583	.357	.300	.0624	2.11
		7	2 molds	.475	.290	.215	.0296	
Hessland, p. 171	*Conchoides circumstriata* Hessland	8	1 valve	2.56	1.42	1.35	4.9075	1.86
		7	1 valve	2.26	1.27	.92	2.6406	1.64
		6	2 valves	1.670	1.055	.915	1.6121	
Hessland, p. 168	*Conchoides* sp. *D* (sine nomine)	Adult	1 valve	2.14	1.28	1.15	3.1500	2.04
		8	1 valve	1.63	1.05	.90	1.5404	
Hessland, pp. 157–158	*Conchoides meganotifera* Hessland Type α	Adult	1 valve	1.98	1.16	1.00	2.2968	1.95
		8	3 valves	1.560	.980	.770	1.1772	2.23
		7	2 valves	1.195	.755	.585	.5278	1.74
		6	2 valves	.965	.615	.510	.3027	2.27
		5	2 valves	.690	.465	.415	.1332	1.81
		4	2 valves	.555	.390	.340	.0736	

* Hessland, 1949, p. 376, line 19: H should read .35 instead of .55 (Hessland, personal communication).

TABLE III.—MEAN DIMENSIONS OF OSTRACOD CARAPACES AND VALVES IN VARIOUS INSTARS OF SIX SPECIES, AND THE VOLUME INCREASES COMPUTED FOR THE MOLT STAGES

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, pp. 159–161	*Conchoides meganotifera* Hessland Type β	Adult	1 carapace	1.72	1.09	0.86	1.6123	2.08
		8	3 carapaces	1.300	.853	.700	.7762	
		8	6 valves	1.260	.832	.693	.7265	1.80
		7	2 valves	1.02	.640	.620	.4047	1.97
		6	1 valve	.79	.51	.51	.2055	2.47
		5	1 valve	.63	.40	.33	.0832	
Hessland, p. 152	*Conchoides micropunctata* Hessland Type α	Adult	2 valves	3.57	2.18	1.65	12.8413	1.86
		8	1 valve	2.74	1.75	1.44	6.9048	
Hessland, p. 176	*Conchoides minuta* Hessland Type α	Adult	4 carapaces	.825	.535	.400	.1766	1.79
		8	8 carapaces	.680	.448	.324	.0987	
		7	—	—	—	—	—	5.00
		6	1 carapace	.42	.26	.18	.0197	
		Adult	3 valves	.810	.503	.430	.1752	2.14
		8	4 valves	.645	.403	.315	.0819	
Hessland, p. 177	*Conchoides minuta* Hessland Type β	Adult	1 valve	.82	.51	.52	.2175	1.66
		8	6 valves	.680	.445	.432	.1307	2.14
		7	2 valves	.53	.35	.33	.0612	1.55
		6	1 valve	.47	.30	.28	.0395	
Hessland, p. 238	*Conchoprimites reticulifera* Hessland	Adult	1 valve	1.32	.89	.65	.7636	2.19
		8	1 valve	1.06	.70	.47	.3487	1.58
		7	2 valves	.890	.620	.400	.2207	
Hessland, p. 269	*Ctenentoma macroreticulata* Hessland	Adult	3 valves	1.273	.723	.670	.6167	2.36
		8	3 valves	.937	.550	.507	.2613	1.90
		7	3 valves	.723	.453	.420	.1376	2.24
		6	5 valves	.544	.340	.332	.0614	2.08
		5	3 valves	.420	.260	.270	.0295	

TABLE IV.—MEAN DIMENSIONS OF OSTRACOD VALVES AND INTERNAL MOLDS IN VARIOUS INSTARS OF SEVEN SPECIES, AND THE VOLUME INCREASES COMPUTED FOR THE MOLT STAGES

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, pp. 277–8	*Ctenentoma plana* Hessland Types *a* and *b*	Adult	2 valves	1.215	0.820	0.535	0.5330	
		8	4 valves	.940	.615	.443	.2561	2.08
		7						3.08
		6	1 valve	.63	.40	.33	.0832	
	Ctenoloculina cicatricosa (Warthin)	Adult	27 valves	.874	.474	.198	.0820	
		8	54 valves	.686	.369	.158	.0400	2.05
		7	33 valves	.541	.288	.130	.0203	1.97
		6	12 valves	.441	.235	.108	.0112	1.81
Hessland, p. 246	*Euprimitia macroreticulata* Hessland	Adult	3 valves	.517	.367	.263	.0499	
		8	3 valves	.427	.280	.210	.0251	1.99
Hessland p. 248	*Euprimitia planopunctata* Hessland	Adult	5 molds	.650	.414	.282	.0759	
		8	3 molds	.530	.317	.237	.0398	1.91
		7	2 molds	.435	.270	.195	.0229	1.74
Hessland, p. 255	*Eurychilina dorsotuberculata* Hessland	Adult	1 valve	1.19	.64	.37	.2818	
		8	2 valves	.915	.545	.325	.1621	1.74
		7	2 valves	.695	.420	.210	.0613	2.64
Hessland, p. 301	*Glossopsis acuta* Hessland	Adult	8 valves	1.100	.670	.508	.3744	
		8	3 valves	.943	.573	.426	.2302	1.63
		7	4 valves	.733	.455	.338	.1127	2.04
Hessland, p. 309	*Glossopsis clavata* Hessland	Adult	9 valves	.917	.583	.452	.2416	
		8	13 valves	.714	.458	.367	.1200	2.01
		7	1 valve	.51	.32	.28	.0457	2.63
		6	3 valves	.417	.260	.227	.0246	1.86
		5	1 valve	.37	.21	.20	.0155	1.59

TABLE V.—MEAN DIMENSIONS OF OSTRACOD VALVES AND INTERNAL MOLDS IN VARIOUS INSTARS OF EIGHT SPECIES, AND THE VOLUME INCREASES COMPUTED FOR THE MOLT STAGES

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, p. 314	*Glossopsis depressolimbata* Hessland	Adult	1 valve	0.93	0.62	0.37	0.2133	
		8	1 valve	.81	.49	.35	.1389	1.54
		7	2 valves	.630	.400	.280	.0706	1.97
Hessland, p. 298	*Glossopsis lingua* Hessland	Adult	1 valve	1.25	.74	.56	.5180	
		8	14 valves	1.020	.642	.453	.2966	1.75
Hessland, p. 304	*Glossopsis tenuilimbata* Hessland	Adult	1 valve	1.12	.64	.61	.4373	
		8	6 valves	.905	.535	.460	.2227	1.96
		7	8 valves	.705	.418	.338	.0996	2.24
		6	5 valves	.610	.346	.286	.0604	1.65
		5	4 valves	.463	.278	.223	.0287	2.10
		4	1 valve	.42	.24	.20	.0202	1.42
Hessland, p. 262	*Laccochilina centrotuberculata* Hessland	Adult	2 valves	1.190	.745	.385	.3413	
		8	1 valve	1.01	.63	.33	.2100	1.63

TABLE V—*Continued*

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, p. 263	*Laccochilina densituberculata* Hessland	Adult	1 valve	1.12	.62	.36	.2500	1.58
		8	3 valves	.927	.533	.320	.1581	
Hessland, p. 259	*Laccochilina dorsoplicata* Hessland	Adult	1 valve	1.37	.86	.70	.8247	2.24
		8	3 valves	1.150	.687	.467	.3690	2.12
		7	3 valves	.910	.557	.343	.1739	
		8	2 molds	1.095	.605	.500	.3312	2.28
		7	3 molds	.807	.497	.363	.1456	
Hessland, p. 264	*Laccochilina levis* Hessland	Adult	1 valve	1.02	.60	.40	.2448	2.58
		8	1 valve	.72	.44	.30	.0950	
Hessland, p. 194	*Macronotella reticulata* Hessland	Adult	3 valves	.843	.533	.463	.2080	2.11
		8	2 valves	.650	.415	.365	.0985	

TABLE VI.—MEAN DIMENSIONS OF OSTRACOD VALVES AND INTERNAL MOLDS IN VARIOUS INSTARS OF FOUR SPECIES, AND THE VOLUME INCREASES COMPUTED FOR THE MOLT STAGES

Source	Species	Instar	Specimens	Length mm.	Height mm.	Width mm.	L×H×W mm.³	Volume Increase
Hessland, p. 325	*Ogmoopsis nodulifera* Hessland	Adult	4 valves	1.073	0.670	0.570	0.4098	1.87
		8	2 valves	.885	.545	.455	.2195	
		8	3 molds	.876	.527	.453	.2091	2.04
		7	6 molds	.683	.412	.365	.1027	2.53
		6	1 mold	.50	.29	.28	.0406	
Hessland, p. 200	*Pinnatulites procera* (Kummerow)	Adult	2 valves	1.860	1.030	.800	1.5327	2.36
		8	2 valves	1.365	.800	.595	.6497	
		7	—	—	—	—	—	4.62
		6	2 valves	.820	.445	.385	.1405	
Hessland, pp. 210–211	*Primitiella brevisulcata* Hessland	Adult	20 valves	.641	.349	.321	.0718	1.92
		8	2 valves	.505	.290	.255	.0373	1.72
		7	1 valve	.41	.23	.23	.0217	2.82
		6	1 valve	.27	.15	.19	.0077	
Hessland, p. 356	*Steusloffia polynodulifera* Hessland	Adult	4 valves	1.220	.778	.803	.7622	1.82
		8	3 valves	.990	.657	.643	.4182	1.76
		7	1 valve	.80	.53	.56	.2374	1.72
		6	2 valves	.715	.430	.450	.1384	
		8	1 mold	1.02	.64	.60	.3917	2.04
		7	3 molds	.827	.493	.470	.1916	1.79
		6	1 mold	.62	.41	.42	.1068	1.83
		5	1 mold	.52	.34	.33	.0583	1.84
		4	1 mold	.44	.30	.24	.0317	

of height and width respectively as compared with length. Because Huxley's formula applies to all instars of a species,

$$H_{(n+1)}=b'L_{(n+1)}{}^{k'}, \qquad H_n=b'L_n{}^{k'},$$
$$W_{(n+1)}=b''L_{(n+1)}{}^{k''}, \quad \text{and} \quad W_n=b''L_n{}^{k''}.$$

Since

$$L_{(n+1)}=L_n(C+1),$$

then

$$\left[\frac{H_{(n+1)}}{b'}\right]^{1/k'}=\left[\frac{H_n}{b'}\right]^{1/k'}(C+1),$$

or

$$H_{(n+1)}=H_n(C+1)^{k'}=H_n(C_2+1)$$

and

$$\left[\frac{W_{(n+1)}}{b''}\right]^{1/k''}=\left[\frac{W_n}{b''}\right]^{1/k''}(C+1),$$

or

$$W_{(n+1)}=W_n(C+1)^{k''}=W_n(C_3+1).$$

From Przibram's formula, it is true also that

$$(C+1)^{1+k'+k''}=2.$$

Thus, the constant differential growth ratios, like the fixed percentages in Brooks' Law, are interrelated. If the constant differential growth ratio of height to length is large, the constant differential growth ratio of width to length must be small for the species.

METHODS OF MEASURING THE VOLUME OF A CARAPACE

Methods involving the displacement of a liquid are not sufficiently accurate to measure the volume of a solid body as small as the carapace of an ostracod. The volume of a carapace can be computed from certain areas and/or linear measurements, with possible small errors arising from the instruments used for measuring and with possible larger errors arising from the shape of the ostracod and from the nature of computations used.

Method A (see fig. 1), although it is the most accurate, is the most difficult and time-consuming. It requires construction of outline drawings (with a camera lucida) of lateral, dorsal, and anterior views of the carapace, and measurement (with a planimeter) of the area enclosed by each outline. The areas of the drawings can be reduced to correspond to those of the specimen. The square root of the products of the three areas of the specimen is the volume of a solid having the same three outlines. The only specimens whose volumes will not be accurately measured by this method are those having depressions, such as large pits or depressed hinge lines, which are not shown in any of the three outlines.

Method B (see fig. 1) requires construction of outline drawings of lateral and dorsal views of the carapace, measurement of the area of each drawing, reduction of these areas to the scale of the specimen, and measurement of the length. The product of the two corrected areas divided by the length of the specimen is the volume of any solid having these two outlines. Volumes determined by this method are inaccurate for specimens with depressions or with structures whose size can be seen only in end view, such as knobs, bulbs, and frills.

Method C (see fig. 1) requires construction of an outline drawing of the carapace as seen in lateral view, measurement of the area with a planimeter, reduction of this area to the scale of the specimen, and measurement of the width of the carapace. The product of the corrected area and the width is the volume of a solid formed by a generatrix, with the same shape as the lateral outline of the carapace, moved along an axis for a distance equal to the width of the carapace. This method is inaccurate for carapaces with depressions or structures whose size can be seen only in end view; in addition, the figure obtained by this method is the same for two specimens with identical widths and lateral outlines, although the outline in dorsal view may be subquadrate for one and lanceolate for the other.

Method D (see fig. 1) requires measurement of greatest length, height, and width of the carapace. The product of these three dimensions is the volume of a rectangular parallelepiped having these three principal measurements. The product is the same for any two specimens of the same measurements, although the outline in lateral view may be subrectangular for one and elliptical for the other. This is the easiest method to apply, but the least accurate.

CONCLUSIONS

The investigations of Przibram, Brooks, and Huxley have discovered three phases

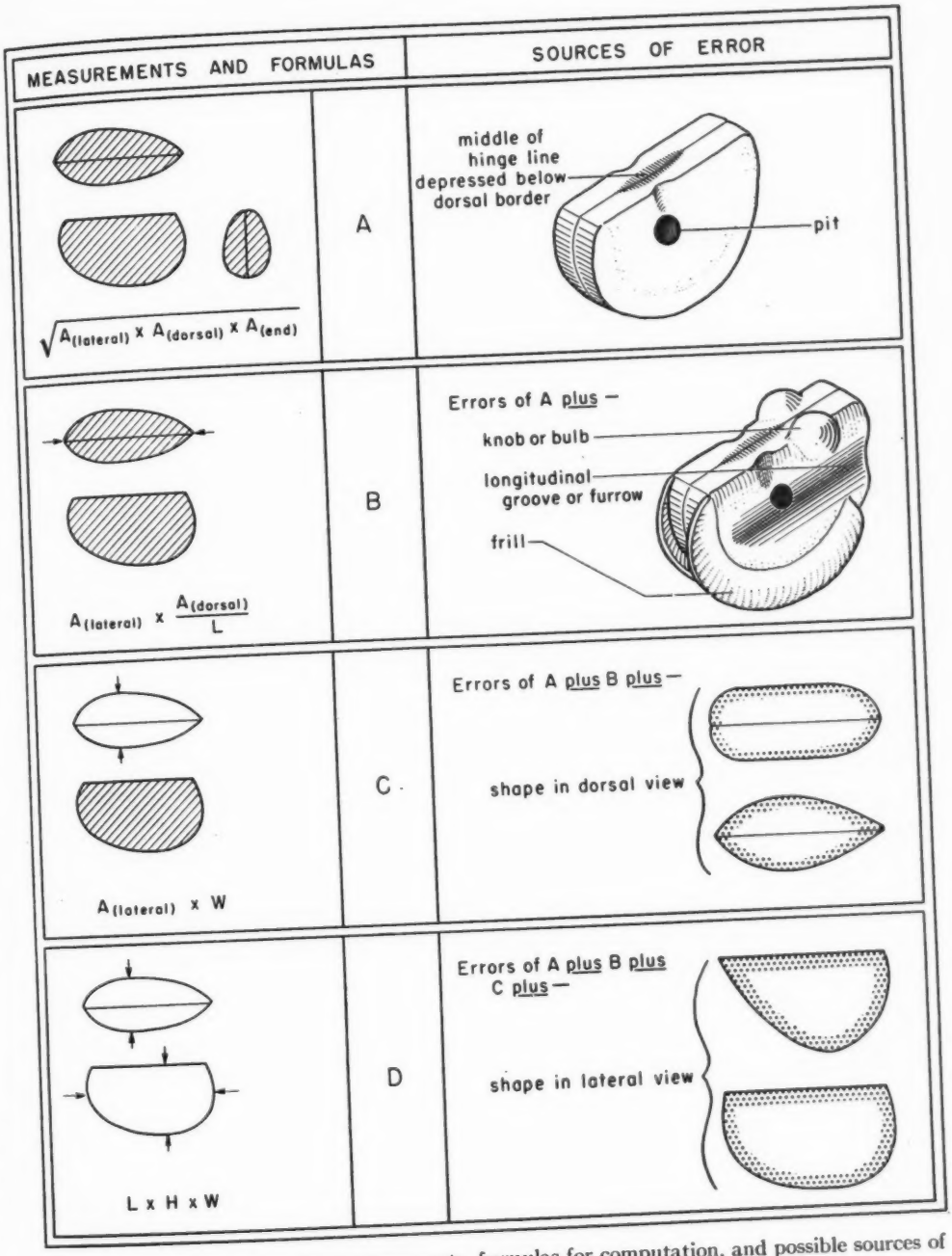


FIG. 1—Diagram showing the measurements, formulas for computation, and possible sources of error in four methods of measuring the volume of an ostracod carapace.

of the basic plan of arthropod growth. Each ostracod spends most of its life in fixed instars, with short intervals called molt stages during which it increases in size and complexity. During each molt stage the animal grows to twice its previous size. If its proportions of the carapace change, they change progressively throughout the ontogeny, and each dimension has its own rate of increase, which is related to the rates of other dimensions.

My studies of ostracod growth (1951a, pp. 234–235; 1951b, pp. 94–116) indicate that there may be two factors which modify the general plan as applied to carapaces. First, the carapace is only part of the ostracod's anatomy, and must share the growth with appendages, glands, and other soft parts. Consequently, the doubling in size of the total animal may not be reflected exactly in the increase of the carapace. Second, the adult ostracod differs functionally and morphologically from the immature instars. It is possible that development of the final instar may not proceed in the same pattern as that of the immature instars.

Additional studies of carapaces, made accurately for numerous specimens of each species, will confirm the concepts discussed in this paper or will find the nature of the exceptions.

MANUSCRIPT RECEIVED JULY 26, 1951

LITERATURE CITED

FOWLER, G. H., 1909, The Ostracoda. Biscayan Plankton, Part XII: Trans. Linnean Soc., Zool., vol. 10, pt. 9, pp. 219–336.

HESSLAND, I., 1949, Investigations of the Lower Ordovician ostracods of the Siljan district, Sweden: Bull. Geol. Instit. Upsala, vol. 33, pp. 97–408.

HUXLEY, J. S., 1924, Constant differential growth-ratios and their significance: Nature, vol. 114, p. 895.

——, 1932, Problems of relative growth. London: Methuen and Co., Ltd. pp. 6–8.

KESLING, R. V., 1951a, Mechanical solution of formulas for growth rates: Contrib. Mus. Paleo. Univ. Michigan, vol. 8, no. 10. pp. 231–237.

——, 1951b, The morphology of ostracod molt stages: Ill. Biol. Monographs, vol. 21, nos. 1–3, pp. 1–324.

PRZIBRAM, H., 1931, Connecting laws in animal morphology. Four lectures held at the University of London, March, 1929. London: Univ. of London Press, 62 pp.

SOHN, I. G., 1950, Growth stages in fossil ostracodes. Amer. Jour. Sci., vol. 248, pp. 427–434.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 781–783, 3 TEXT FIGS., SEPTEMBER 1952

A *MANTICOCERAS* FROM MISSOURI

A. G. UNKLESBAY
University of Missouri, Columbia, Missouri

ABSTRACT—The genus *Manticoceras* which is widespread in Upper Devonian beds is now known from Missouri. One specimen of *Manticoceras regulare* Fenton and Fenton from the Snyder Creek shale is described. This is the first goniatite to be reported from the Devonian of Missouri.

THE genus *Manticoceras* is widespread geographically, being known rather widely in Europe and North America, and also occurring in Australia, China, Siberia, and northern Africa. It is somewhat surprising that it has not been reported from South America but as yet no goniatites have been reported from the Devonian of that continent. According to Miller (1938a) "Almost two-fifths of the species of Devonian ammonoids that are known from America belong in this genus." In the United States the genus has been reported from New York, Indiana, and Iowa. In Canada it is known from the vicinity of Great Slave Lake in the Mackenzie District, from Jasper Park in Alberta, and from the James Bay region in northeastern Ontario.

Stratigraphically, however, *Manticoceras* is rather limited. In North America most of its occurrences are in beds referred to the Finger Lakes and Chemung of the Senecan, and the lower part of the Casadaga of the Chautauquan. One species has been reported from the Tully which is regarded as Taghanic in age. In western Canada *Manticoceras* occurs in the Bosworth sandstone member of the Imperial formation and is used by Warren and Stelck (1950) to designate their *Manticoceras* zone which is widespread in western Canada. This zone lies just above their *Spirifer strigosus* zone which "is probably represented in the Lime Creek shales of Iowa."

In Europe this genus is limited to the lower part of the "Oberdevonstufe I" and although precise correlations are not available it is presumed that those from Asia and Africa are also from the lower part of the Upper Devonian (Miller, 1938a). The Australian forms have been reported (Teichert 1941, 1943) from the Kimberley District of Western Australia. Here the *Manticoceras* fauna is now well known and its correlation well established. Teichert divides it into two assemblages both of which he correlates with the German Oberdevonstufe I.

Despite the widespread occurrence of this genus and despite the great amount of detailed work done on the Devonian of Missouri, *Manticoceras* has not heretofore been known in Missouri, nor has it been reported in the Devonian of United States south of Iowa, west of the Mississippi River. In fact, no goniatite of any kind has been previously reported from the Devonian of Missouri.

In the spring of 1950 the writer found a poorly preserved specimen on a Snyder Creek shale exposure along Missouri Highway 19 in Montgomery County and this specimen is herein described. Thanks are here extended to Dr. A. K. Miller for his valuable suggestions which aided in completion of this report.

MANTICOCERAS REGULARE Fenton and Fenton

Text figures 1, 2

? *Goniatites* sp. CALVIN, 1897, Iowa Geol. Survey, vol. 7, p. 168.

Manticoceras pattersoni FENTON, 1919, Am. Jour. Sci., 4th ser., vol. 48, p. 373.

Manticoceras regulare FENTON and FENTON, 1924, Univ. Mich., Mus. Geol., Contr., vol. 1, pp. 196–197, pl. 39, figs. 1–3.

? *Manticoceras regulare* ? MILLER, 1936, Pan-Am. Geol., vol. 65, pp. 336–337.

Manticoceras regulare MILLER, 1938, Iowa Acad. Sci., Proc., vol. 43, pp. 231, 234, pl. 1, figs. 1–4, 11, 12. —— 1938, Geol. Soc. America, Spec. Pap. 14, pp. 97–99, pl. 21, fig. 1, pl. 22, figs. 1–6. —— (1936) Type invertebrate fossils, of North America (Devonian), Ammonoidea 28. —— KINDLE and MILLER, 1939, Geol. Soc. America, Spec. Pap. 23, p. 75.

The specimen under consideration is rather poorly preserved but exhibits significant characteristics so that specific identification is not difficult. It has been a pyritized mold but the outer portion is now altered and consists of limonite and hematite.

This specimen consists of an internal mold of approximately half of a volution which was about 24 mm. in diameter. Near the midlength of the specimen the height of the shell from umbilical wall to venter is about 9.5 mm. One side of the specimen has been broken away but the original maximum width of the volution near the midlength has been approximately 7 mm. This maximum width was attained just ventrad of the umbilical shoulder. The lateral zones of the test are only slightly curved and converge slightly toward the ventral zone. The venter is broadly rounded. Growth lines have not been preserved on this specimen.

The external sutures are well preserved on the specimen as raised lines and can be easily traced from the venter to the umbilical wall. Each suture consists of a symmetrical broad unequally trifid ventral lobe in which the secondary saddles are broadly rounded and the secondary lobes are sharply pointed. The secondary lobe is bordered by a broad high, asymmetrical saddle, occupying most of the lateral zone, which is then bordered by a relatively small blunt lobe adjacent to the umbilical shoulder. A small slightly rounded saddle continues over the umbilical shoulder. The internal sutures are not visible. See Figure 3.

1 2

FIGS. *1* and *2*—Ventral and lateral views (×4) of specimen of *Manticoceras regulare* Fenton and Fenton from Snyder Creek shale, Montgomery County, Missouri.

Remarks.—Miller (1935) has pointed out that *Manticoceras regulare* Fenton and Fenton may be conspecific with *M. sinuosum* (Hall).

The Missouri specimen exhibits no characteristics by which it could be well differentiated from either of these species. However, inasmuch as it occurs in beds which may have actual continuity with the beds in Iowa which yielded Fenton's specimen, it

seems more logical to associate it with the Iowa forms.

Occurrence.—This specimen was found in the lower part of the Snyder Creek shale in

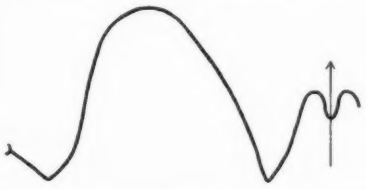


FIG. 3—Suture pattern of *Manticoceras regulare* Fenton and Fenton, ×4. Based on specimen from Snyder Creek shale, Montgomery County, Missouri.

a road cut along Missouri Highway 19 on Big Spring Hill, $SE\frac{1}{4}SE\frac{1}{4}SE\frac{1}{4}$ sec. 21, T. 47 N., R. 5 W., Montgomery County, Missouri.

Repository.—University of Missouri, No. 9207.

REFERENCES

CALVIN, S., 1897, Geology of Cerro Gordo County [Iowa]. Iowa Geol. Surv., vol. 7, pp. 117–195.

FENTON, C. L., 1919, The Hackberry stage of the Upper Devonian: Am. Jour. Sci., 4th ser., vol. 48, pp. 355–376.

FENTON, C. L. and FENTON, M. A., 1924, The stratigraphy and fauna of the Hackberry stage of the Upper Devonian: Mich. Univ., Museum Geol., Contr., vol. 1, pp. 1–260, pls. 1–45.

KINDLE, E. M., and MILLER, A. K., 1939, Bibliographic index of North American Devonian Cephalopoda: Geol. Soc. Amer., Spec. Pap. 23, 179 pp.

MILLER, A. K., 1936, Devonic ammonoids of Iowa: Pan-Am. Geol., vol. 65, pp. 336–338.

——, 1936, Ammonoidea, in Type invertebrate fossils of North America (Devonian), Wagner Free Inst. Sci., 50 cards, figs.

——, 1938, Iowa Devonian ammonoids: Iowa Acad. Sci., Proc., vol. 43, pp. 231–234, pl. 1.

——, 1938a, Devonian ammonoids of America: Geol. Soc. Amer., Spec. Pap. 14, 262 pp., 39 pls.

TEICHERT, CURT, 1941, Upper Devonian goniatite succession of Western Australia. Am. Jour. Sci., vol. 239, pp. 148–153.

——, 1943, The Devonian of Western Australia: Pt. I. Am. Jour. Sci., vol. 241, pp. 69–94, Pt. II, pp. 167–184.

WARREN, P. S., and STELCK, C. R., 1950, Succession of Devonian faunas in Western Canada: Royal Soc. Canada, Trans., vol. 44, ser. 3, sec. 4, pp. 61–78.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 784–788, PLS. 112, 113, 1 TEXT FIG., SEPTEMBER 1952

THE ARMS OF *PERIMESTOCRINUS*

HARRELL L. STRIMPLE
Bartlesville, Oklahoma

ABSTRACT—This study deals primarily with the description of *Perimestocrinus hexagonus*, n. sp. and *P. planus*, n. sp. Both are from the Ochelata group, Missourian, of Oklahoma. Attention is given to modes of arm branching, and variations in the arrangement of plates of the posterior interradius is discussed at some length.

THE genus *Perimestocrinus* was proposed by Moore and Plummer (1937) with *Hydreionocrinus noduliferous* Miller and Gurley (1894) as the genotype species. Only the proximal portions of the arms of this species are known. They are uniserial and bifurcate on the rather elongated, non-spiniferous first primibrachials ($PBrBr_1$). As many as four SBrBr are preserved in a single ray without subsequent bifurcation.

Aside from the arm structure, basis for separation from *Plaxocrinus* Moore and Plummer (1938) and other comparable forms has been the presence of a deep, narrow basal concavity in the dorsal cup of *Perimestocrinus*.

In 1939, *Plaxocrinus politus* Moore was described from the Virgilian. A good portion of the arms were preserved and it is presumed the species was ascribed to *Plaxocrinus* because of the spinose nature of the axillary primibrachials. The dorsal cup of this species and of *Plaxocrinus praevalens* Moore (1939) is more comparable to *Perimestocrinus* and the species are so assigned by this author. Although a much closer relationship between these two genera is apparent than originally thought, separation on the basis of characteristic differences in the nature of the dorsal cups is possible and desirable.

Description of *P. moseleyi* Strimple (1951a) has given a rather comprehensive knowledge of the arm structure of the genus. Two species having well preserved arms are described below as *Perimestocrinus hexagonus*, n. sp. and *P. planus*, n. sp.

Comparison with the arm structure of *Plaxocrinus oeconomicus* Strimple (1951a) and *Plaxocrinus gloukosensis* Strimple (1951b) discloses identical mode of branching and closely comparable structures. Normally, *Plaxocrinus* has low axillary PBrBr which are extended as long stout

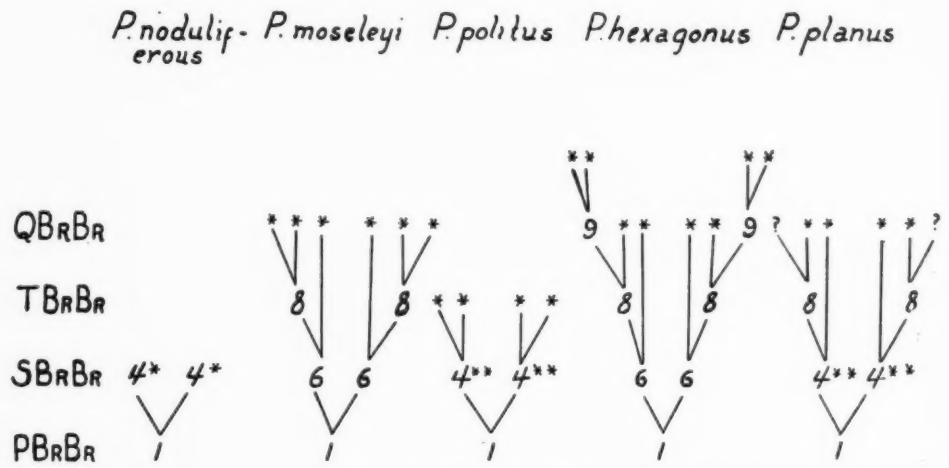


FIG. 1—Analysis of arm structure in species of *Perimestocrinus*. Single asterisks indicate points at which there is no evidence of further branching. Double asterisks signify a maximum of six.

spines. The axillary PBrBr of *Perimestocrinus* are usually elongated, and may or may not produce spines. When present, the spines are normally somewhat smaller than those of *Plaxocrinus* and occur toward the distal tips of the plates.

The genus *Pirasocrinus* Moore and Plummer (1940) also has arms which bifurcate on the first PBrBr and the sixth SBrBr; however, subsequent branching takes place in both outer and inner rays. In *Perimestocrinus*, the inner rays remain unbranched after the second dichotomy.

Several closely related Pennsylvanian-Permian forms have arms which bifurcate the second time on or about the second SBrBr. These are *Sciadiocrinus* Moore and Plummer (1938), *Schistocrinus* Moore and Plummer (1940) and *Neozeacrinus* Wanner (1937).

SPECIES ASSIGNED TO *PERIMESTOCRINUS*

Hydreionocrinus noduliferous Miller and Gurley
Synonymy—*Perimestocrinus nodulifer* Moore and Plummer
Perimestocrinus pumilis Moore and Plummer
Perimestocrinus teneris Moore and Plummer
Eupachycrinus parvus Miller and Gurley
Plaxocrinus politus Moore
Plaxocrinus praevalens Moore
Perimestocrinus moseleyi Strimple
Perimestocrinus subtilis Moore
Perimestocrinus formosus Moore and Plummer
Perimestocrinus impressus Moore and Plummer
Perimestocrinus calyculus Moore and Plummer
Delocrinus excavatus Weller
Perimestocrinus hexagonus, n. sp.
Perimestocrinus planus, n. sp.

DESCRIPTION OF SPECIES PERIMESTOCRINUS HEXAGONUS Strimple, n. sp.

Plate 112, figures 1–3; plate 113, figures 1–7

This is one of the more abundant species found in the crinoidal zones of the Wann formation. The holotype and normal representatives have broad posterior interradii occupied by three large anal plates in normal (Primitive Type) arrangement. Under this condition the dorsal cup has a hexagonal outline when viewed from above or below. A large percentage of the dorsal cups show variation in the anal arrangement and this is discussed at length below. Dorsal cup is unusually shallow for the genus and has a rather broad basal concavity. Maximum width of the holotype is 22.7 mm., height 4.0 mm. Over-all length of the complete crown of a figured paratype is 43.2 mm.

Five IBB form a subhorizontal, pentagonal shaped disk at the bottom of the basal concavity. They are covered to a large extent by the proximal columnal. Five BB are fairly long elements, forming an irregular, petal-shaped circlet. The upper extremity of post. B is usually truncated and is normally in contact with anal X. Proximal portions of BB are curved strongly into the basal invagination and recurve before contact with IBB, causing an overhanging effect. Only the distal tips of BB are visible in side view of the cup. An elongated, groove-like depression is present in the median portion of each BB. Five RR are large, wide, pentagonal plates. Arm articulating facets are directed outwardly and have deep V-shaped intermuscular notches. Post. IR is normally occupied by three elongated plates; anal X resting on post. B and on RA to the right below; RA is obliquely placed, in contact to the right with r. post. B and to the left with post. B and anal X; RX is bordered below by RA, to the right by r. post. R and to the left by anal X, and extends well above the upper limits of the cup. Sutures between plates of the BB and RR circlets are well impressed and the plates are tumid. Fine granulations are present but are not readily visible without mild magnification.

There are approximately 40 uniserial arms. First branching is on the first PBrBr in all rays. Lower portions of these axillary PBrBr are mildly swollen but the spine-like processes occur in the distal portions of the plates. Another regular bifurcation takes place on the sixth or seventh SBrBr in all rays. Thereafter, the inner rays remain unbranched to their terminations. All outer rays branch again, with the subsequently formed inner rays remaining unbranched. One more bifurcation takes place in the outer rays, and at the same level in other arms a normal brachial often produces a small spine.

The anal sac is in the form of a large tube, terminating with an umbrella-like development composed of large flat plates directed subhorizontally. The tube plates are thin, hexagonal and have well-developed pore slits along the lateral sides.

Thin, round columnals, with well-impressed sutures, form the proximal portion of the column. The lumen is minute and round.

Relationship.—Crowns of *P. hexagonus* are readily distinguished by the thin, delicate nature of the arms. The dorsal cup is lower and the basal concavity is wider than normal for the genus. In these later respects the species is somewhat comparable to some species of *Plaxocrinus*, but that genus does not have the overhanging effect found at the junction of BB with IBB.

Variations in plates of the posterior interradius.—One hundred and eighty-four specimens were examined to determine the arrangement of the anal plates, and have been divided as follows:

Primitive Type.—All forms in which anal X, at its lower end, has more or less wide contact with post. B, and lower end of RA has a similar connection with r. post. B.

Primitive Type A.—As above, but with the lower end of RA detached from r. post. B.

Advanced Type.—Where the RA has a direct connection with l. post. R and anal X is entirely separated from post. B.

Advanced Type A.—Similar to above, but with lower end of RA detached from r. post. B.

	Primitive Type	Primitive Type A	Advanced Type	Advanced Type A	Other	Abnormal	Symmetrical
AFTER WRIGHT:							
Hydreionocrinus	125[1]	3	1	1	0	0	0
Less St. Monans	65	0	0	0	0	0	0
	60	3	1	1	0	0	0
Zeacrinus koninckí	49	5	231	56	0	1	0
Ureocrinus globularia	54	0	480	8	0	0	0
Phanocrinus calyx	771	40	115	67	3	3	1
AFTER STRIMPLE:							
Phanocrinus[2]	272	1	18	6	0	3	0
Perimestocrinus[3]	22	18	5	13	0	0	0
Perimestocrinus hexagonus	103	7	33	40	0	1	0

[1] This figure is distorted by the presence of 65 dorsal cups from the "White Limestone" of St. Monans, which appear to be a distinct species, and are remarkably constant in all characteristics, according to Wright.

[2] Of the Fayetteville formation, Chester, northeastern Oklahoma (1948b).

[3] Of the Dewey limestone, Skiatook group, Missourian, northeastern Oklahoma. This was presented as "Peremistocrinus" by the author (1948a), with correction to *Perimestocrinus* appearing in Geol. Mag., vol. 86, p. 127.

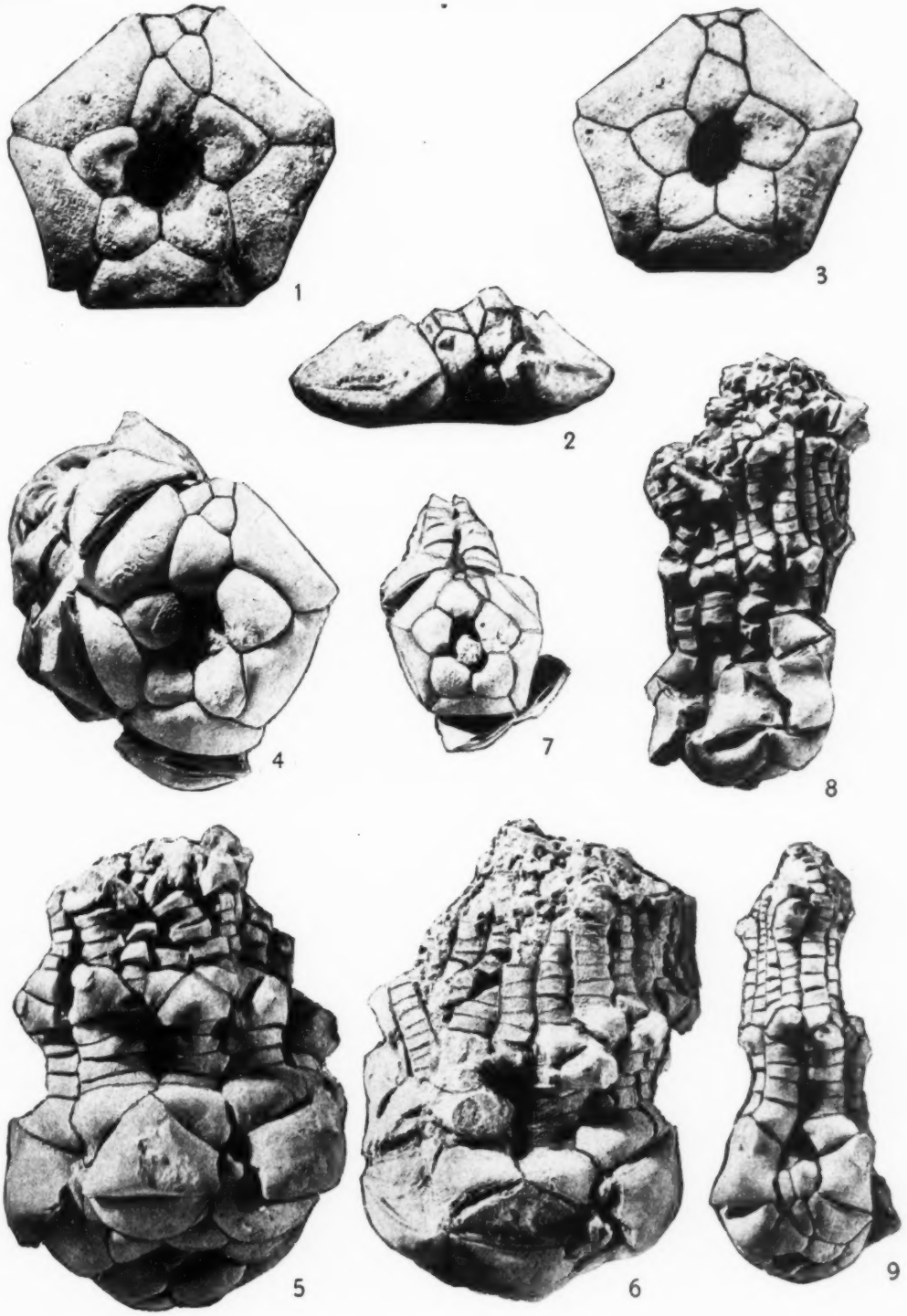
Examination of the statistics given above discloses that in observed *Ureocrinus*, *Zeacrinus*, and *Phanocrinus* the dominant variant is "Advanced Type," wherein RA continues to retain contact with r. post. B. but has established contact with l. post. R. As might be expected, the next divergency from norm is loss of contact between RA and r. post. B which is termed "Advanced Type A." *Phanocrinus calyx* also shows a strong tendency toward retention of contact between anal X and post. B, yet RA is migrating away from the r. post. B. This later development is not so pronounced in American species studied by the author, but does exist.

In both studies of *Perimestocrinus* made by the author a large percentage of the specimens tend strongly toward "Advanced

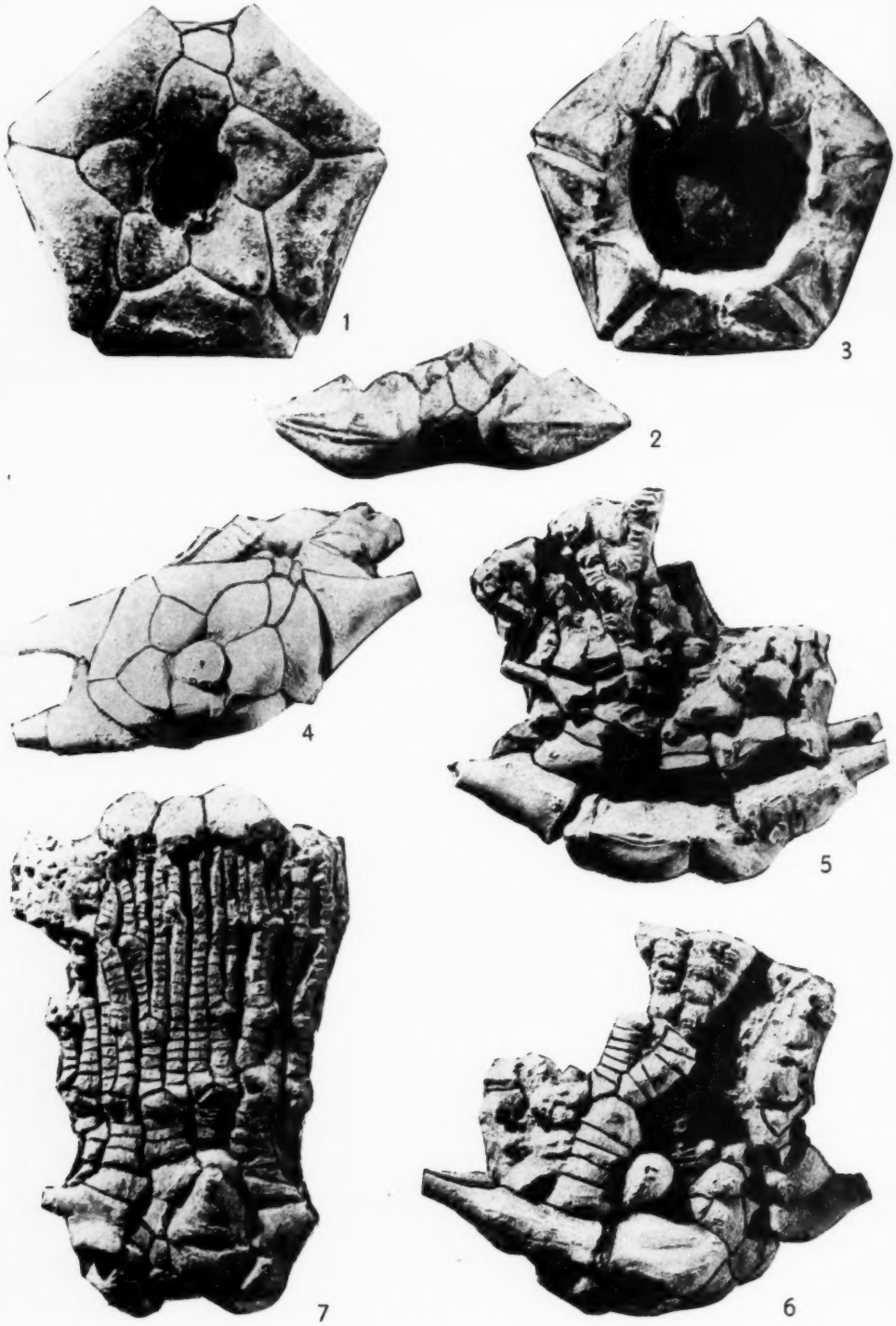
EXPLANATION OF PLATE 112

FIGS. *1–3*—*Perimestocrinus hexagonus* Strimple, n. sp. Holotype viewed from *1*, base and *2*, posterior. Paratype viewed from *3*, base. ×2. (p. 785)

4–9—*Perimestocrinus planus* Strimple, n. sp. Paratype viewed from *4*, base, *5*, left anterior and *6*, right anterior. Holotype viewed from *7*, base, *8*, left anterior and *9*, posterior. ×2. (p. 787)



Strimple, *Perimestocrinus* arms



Strimple, *Perimestocrinus* arms

Type A," and a considerable percentage toward "Advanced Type." Several specimens of *P. hexagonus* show definite signs of resorption of RA, which has been termed "Developmental Trend A" by Strimple (1948a). Other specimens strongly indicate retention of RA as the dominant anal plate which was termed by the author (1948a) as "Developmental Trend C."

Occurrence and horizon.—Holotype and paratypes are from the hill, locally termed "The Mound," just west of the city limits of Bartlesville, Oklahoma. Specimens referable to the species, but not used in this study, have been observed from comparable horizons exposed in Washington and Osage Counties of Oklahoma; crinoid zones of the Wann formation, some 20 feet below the Torpedo sandstone formation, Ochelata group, Missourian, Pennsylvanian.

Types.—Collected by Mrs. Melba L. Strimple and the author. To be deposited in the U. S. National Museum.

PERIMESTOCRINUS PLANUS
Strimple, n. sp.
Plate 112, figures 4–9

Dorsal cup is mildly angular when viewed from above or below, rather shallow, with deeply impressed, small basal invagination. IBB are obscured by proximal columnals but appear to be five. Five BB curve strongly into the invaginated basal area and recurve before contacting the IBB. Post. B is longer than other BB and forms a narrow contact with anal X. R. post. B is considerably wider than other plates of the circlet. Five RR are wide, tumid and pentagonal. Three anal plates are narrow and elongated; RA has either a narrow contact with r. post. B or has entirely lost contact; RX connects with RA below, r. post. R to the right and anal X to the left and is almost entirely above the summit of the cup. Sutures between cup plates are deeply impressed and the plates are tumid.

The small crown, designated as the holotype, is well preserved and has 30 arms; however, a larger paratype indicates the presence of as many as 40 arms. Pinnules are delicate and poorly preserved. First bifurcation takes place on the axillary first PBrBr in all rays and a second branching occurs on the fourth to sixth SBrBr. Thereafter, the inner rays remain unbranched but a third dichotomy is found in subsequently formed outer branches. All axillary BrBr are spinose and a peculiar development occurs in unbranched rays at the level where bifurcation is found in outer rays, in that otherwise normal BrBr become spinose. The arms have well rounded exteriors, and the flattened lateral sides allow for compactness when the arms are closed.

Remnants of an umbrella-like termination of the anal tube have been observed. A few tube plates are exposed in one of the paratypes. These are hexagonal, and marked by low ridges and pronounced pore slits.

The column is composed of moderately thin segments, with sutures impressed. The lumen is small and round. There is no evidence of any type of granulations or ornamentation on the outer surface of the crown.

The crown of the holotype is 30.5 mm. in length. Dorsal cup is 11.3 mm. wide, and 3.2 mm. high.

Remarks.—This species is readily separable from *P. hexagonus* in having a more evenly rounded, deeper dorsal cup, and a smaller basal concavity. In general structure, *P. planus* is very close to *P. moseleyi* Strimple (1951a); however, the latter species has a coarsely granular surface. The dorsal cup of *P. impressus* Moore and Plummer (1940) is somewhat comparable but the surface also appears very granular. Arm structure of *P. planus* indicates close affinity to *Pirasocrinus;* however, the arms of that genus continue to branch in both inner and outer rays after the second dichotomy.

EXPLANATION OF PLATE 113

FIGS. *1–7*—*Perimestocrinus hexagonus* Strimple, n. sp. Large paratype showing arrangement of plates in the posterior interradius termed "Advanced Type A" viewed from *1*, base, *2*, posterior and *3*, summit. Paratype showing portions of the arms and the anal tube viewed from *4*, below, *5*, right anterior and *6*, left posterior. ×2. Paratype showing complete crown with the umbrella-like termination of anal tube viewed from *7*, posterior. ×1.5. (p. 785)

Occurrence and horizon.—Abandoned tank dike in hill some 2½ miles NE of Copan, Washington County, Oklahoma; unnamed shale some 30′ above the Torpedo sandstone formation, Ochelata group, Missourian, Pennsylvanian.

Types.—Collected by Mrs. Melba Strimple and the author. To be deposited in the U. S. National Museum.

REFERENCES

KIRK, EDWIN, 1937, *Eupachycrinus* and related Carboniferous crinoid genera: Jour. Paleontology, vol. 11, pp. 598–607, pl. 84.

MILLER, S. A. and GURLEY, WM. F. E., 1894, Ill. State Mus. Nat. History, Bull. no. 3, pp. 41, 60, pl. 6, figs. 15–17, 22, 23.

MOORE, R. C., 1939, New crinoids from Upper Pennsylvanian and Lower Permian rocks of Oklahoma, Kansas, and Nebraska: Denison Univ. Bull., Jour. Sci. Lab., vol. 34, pp. 223–227, 229–231, pl. 8, figs. 5, 6, text figs. 10, 13, 16.

—— and PLUMMER, F. B., 1937, Upper Carboniferous crinoids from the Morrow subseries of Arkansas, Oklahoma, and Texas: Denison Univ. Bull., Jour. Sci. Lab., vol. 32, pp. 277–285, pl. 14, figs. 5, 10, text figs. 26–30.

——, 1940, Crinoids from the Upper Carboniferous and Permian strata in Texas: Univ. Texas, Publ. no. 3945, pp. 9–468, pls. 1–21.

STRIMPLE, H. L., 1948a, *Peremistocrinus* from the Dewey limestone formation: Geol. Mag., vol. 85, pp. 113–116, pl. 10.

——, 1948b, Notes on *Phanocrinus* from the Fayetteville formation of northeastern Oklahoma: Jour. Paleontology, vol. 22, pp. 490–493, pl. 77, text figs. 1–8.

——, 1951a, Pennsylvanian crinoids from Lake Bridgeport, Texas: Jour. Paleontology, vol. 25, pp. 200–207, pls. 36–39.

——, 1951b, New crinoids from the Pennsylvanian of Kansas: Jour. Paleontology, vol. 25, pp. 374–375, pl. 57, figs. 1–6.

WRIGHT, JAMES, 1926, Notes on the anal plates of *Eupachycrinus calyx* and *Zeacrinus koninckii*: Geol. Mag., vol. 63, pp. 145–164, pls. 15–17.

———, 1927, Some variations in *Ulocrinus* and *Hydreionocrinus:* Geol. Mag., vol. 64, pp. 353–372.

—— and STRIMPLE, H. L., 1945, *Mooreocrinus* and *Ureocrinus* gen. nov., with notes on the family Cromyocrinidae: Geol. Mag., vol. 73, pp. 385–412, pl. 9.

MANUSCRIPT RECEIVED SEPTEMBER 21, 1951

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 789–796, PLS. 114–116, SEPTEMBER 1952

SCHIZOCORALLA FROM THE ORDOVICIAN OF MANITOBA

EDWARD I. LEITH
University of Manitoba, Winnipeg

ABSTRACT—The schizocoral genera *Protaraea* Milne-Edwards and Haime, *Protrochiscolithus* Troedsson and *Pragnellia* Leith, new genus, from the Ordovician of Manitoba are described and illustrated. A new order Protaraeina with a new family Protaraeidae is proposed to include these genera. The hypothetic genus *Protrochiscolithus* proposed by Kiär is also discussed.

THE coral fauna of the Ordovician in Manitoba is a very rich one in its variety of species and large number of specimens. Tabulates and tetracorals are very well represented by many species and together they make up the greater part of the coral fauna. Schizocorals make up the smaller part of the coral fauna and three genera, namely *Protaraea* Milne-Edwards and Haime, *Protrochiscolithus* Troedsson and *Pragnellia* Leith, a new genus, have been identified. In addition to the forms described here there are other schizocoral types in Manitoba, including probably the chain-like forms assigned by Leith (1944) to *Halysites*, which will be described at a later date. Specimens of *Protaraea* are rare and rather poorly preserved. *Protrochiscolithus*, recorded hitherto only from Greenland, is as abundant as some of the tabulate or tetracoral genera and many excellent specimens of this genus have been collected. *Pragnellia* is represented by a single, unique specimen. Although the three genera form only a minor element of the coral fauna they are among the most interesting of the corals collected. The unusually large coralla of *Pragnellia* and especially of *Protrochiscolithus* in Manitoba are a very striking feature for schizocorals.

Protaraea and *Protrochiscolithus* have been classified previously with the Subfamily Protaraeidae in the Family Heliolitidae. They, and also *Pragnellia*, superficially appear to be heliolitids but the corallites in these genera lack the definite platelike corallite walls characteristic of the Heliolitidae. As the genera probably represent aberrant coral types it is therefore exceedingly difficult to classify them. In the present discussion they are grouped together under a new order, Protaraeina, and a new family, Protaraeidae, and placed with the Subclass Schizocoralla of Okulitch even though this may be very much open to question.

The corals described in this report were found in the Stony Mountain formation and the Selkirk member of the Red River formation. The Stony Mountain is Richmond in age and, as pointed out by Twenhofel (1928, p. 67), its fauna is very similar to the faunas of zones 3, 4 and 5 of the Vaureal on Anticosti Island. The Red River formation is immediately below the Stony Mountain formation and, in the writer's opinion, it is also Upper Ordovician in age.

During the early part of 1899 Lindström and Kiär,[1] working independently, published the results of their studies on the heliolitid corals of Sweden and Norway. In the same year Lindström wrote a short critical review of Kiär's work and several years later Kiär (1904), as a reply to Lindström's criticism of his work, published his review of the Silurian Heliolitidae. A brief review and discussion of parts of their work, and others, is given here to serve as an introduction to the study of the Manitoba schizocorals.

Lindström (1899) in his excellent memoir on the Swedish species of heliolitid corals placed *Coccoseris* Eichwald, *Protaraea* Milne-Edwards and Haime, and *Acantholithus*[2] Lindström together in a new family which he named the Coccoseridae. Kiär (1904), however, considered *Coccoseris* to be a synonym of *Protaraea*. He substituted the name Protaraeinae for the Coc-

[1] Also spelt Kiær.

[2] This name is preoccupied by *Acantholithus* Stimpson for a crustacean (Lang, Smith and Thomas, 1940).

coseridae and placed it as a subfamily of the Heliolitidae. Both *Coccoseris* and *Protaraea* are listed as possible valid genera by Zittel-Eastman (1913, p. 112), Zittel-Broili (1924, p. 133) and Lang, Smith and Thomas (1940, p. 106), The question of the synonymy, as raised by Kiär, is mentioned by the authorities just listed. The illustrations of both genera in the published works of Lindström and Kiär show a remarkable similarity between the two genera, and the writer is inclined to agree with Kiär's conclusion that *Coccoseris* Eichwald, 1855 is synonymous with *Protaraea* Milne-Edwards and Haime, 1851. Troedsson (1929, p. 115) recognized the Protaraeinae as a subfamily of the Heliolitidae and stated that *Coccoseris* is synonymous with *Protaraea*. Unfortunately the types for the genera are not available and the final determination of the synonymy will have to await a study of the original material on which the genera were founded.

In the criticism of Kiär's work on the Heliolitidae, Lindström (1899) stated that he considered the Coccoseridae to be a separate family of corals rather than a subfamily of the Heliolitidae for the following reasons:

1. Skeleton composed of closely packed baculi.
2. No distinct theca around the calices.
3. Septa made up of fibrillous, oblique baculi diverging from a central axis compared with the parallel fibrillae one above the other in the septa of the Heliolitidae.

Lindstrom pointed out that baculi are present in both *Propora* and *Diploëpora* of the Heliolitidae. In *Propora* the baculi are not so abundant, nor as large, as in the Coccoseridae; *Diploëpora*, characterized by a double coenenchyma, has a vesicular interior zone and an exterior zone composed of closely packed baculi. Although Lindström recognized the coccoseridean nature of *Diploëpora* and its very close relationship with the Coccoseridae he believed that in the systematic arrangement of the genera of the Heliolitidae it should be placed last as a member among the Plasmoporinae and just before the Coccoseridae. Kiär in his revision of 1904, however, maintained that the characteristic development of baculi in *Heliolites*-like and *Plasmopora*-like forms, in addition to the forms mentioned by Lindström, indicated only a subfamily relationship for the Coccoseridae or Protaraeinae. He stated, as further evidence against Lindström's ideas, that the thecal walls of *Diploëpora* are completely fused with the coenenchyma and that *Trochiscolithus*, which also has a well-developed bacular skeleton, exhibits thecal wall construction just as in the typical Heliolitidae. He believed the septal difference between the Coccoseridae and Heliolitidae to be of no significance.

As mentioned above, Troedsson recognized the Protaraeinae as a subfamily of the Heliolitidae and he included *Protaraea*, *Trochiscolithus* and *Protrochiscolithus* as genera of the subfamily.

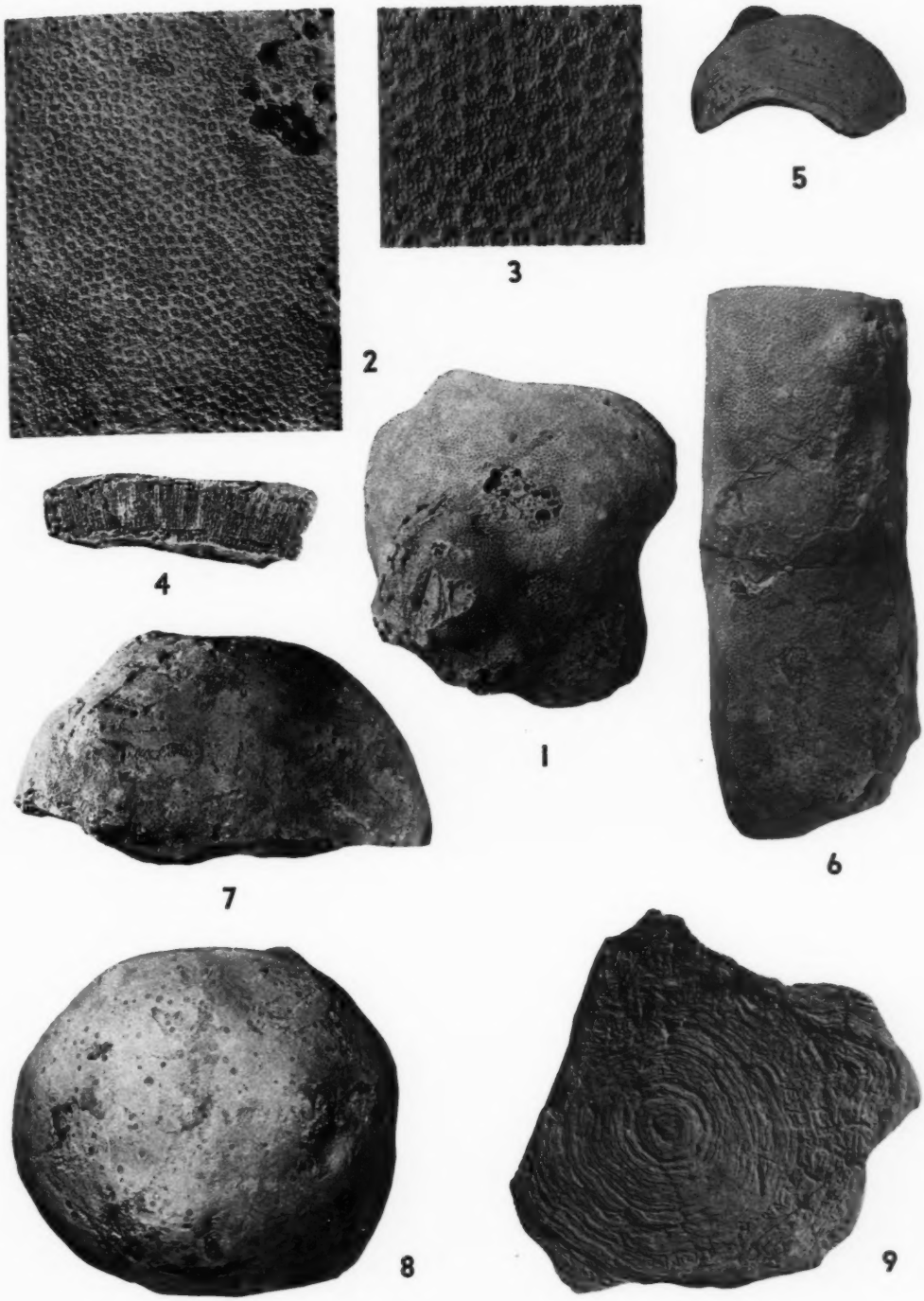
In 1936 Okulitch proposed new order names for the Heliolitidae, Tetradidae and Chaetitidae, and he grouped them in his new subclass Schizocoralla. He did not discuss the Protaraeinae at that time because, as he stated in a personal communication to the writer, material for the study of this type of coral was not available to him. In the Order Heliolitina with the Family Heliolitidae, as defined by Okulitch, the walls of the corallites are fully amalgamated and appear as plate-like partitions between the corallites.

The type of wall described above for the heliolitids has not been observed by the writer in *Protaraea*, *Protrochiscolithus* and

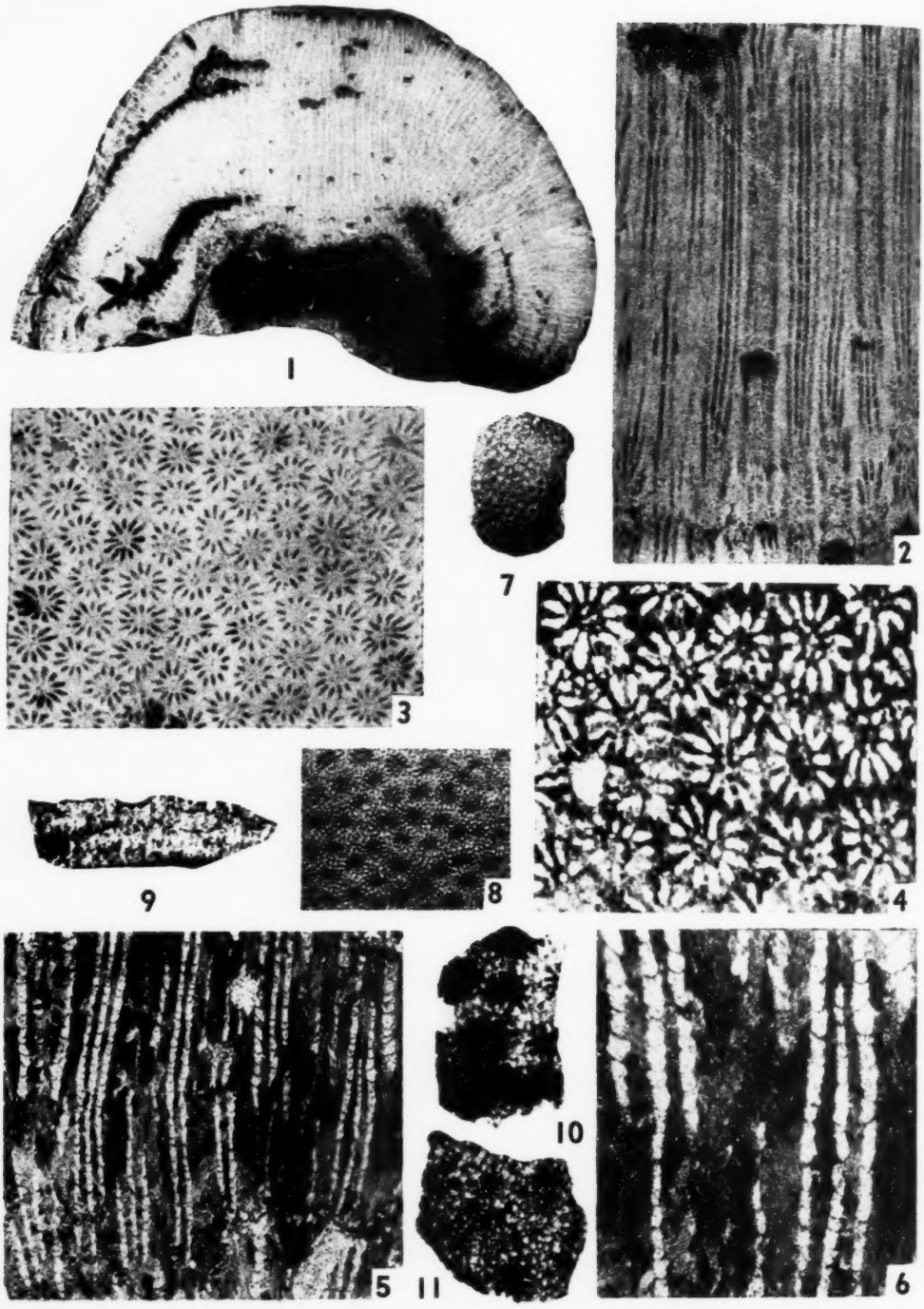
---

EXPLANATION OF PLATE 114

FIGS. *1–9*—*Protrochiscolithus kiaeri* Troedsson. *1–3*, Top view of an irregularly shaped corallum ×1, and parts of surface to show corallites ×1 and ×2; Lockport, Manitoba; Univ. Manitoba 113. *4*, Side view of a weathered corallum ×1; Lockport, Manitoba; Univ. Manitoba 115. *5–6*, Polished end, and top view of a corallum which is encrusted over an orthoconic nautiloid ×1; Lockport, Manitoba; Univ. Manitoba 114. *7–8*, Side and top views of a hemispherical corallum ×1; Garson, Manitoba; Univ. Manitoba 112. *9*, Lower surface of a corallum with peritheca ×1; Garson, Manitoba; Univ. Manitoba 111. (p. 792)



Leith, Ordovician Schizocoralla from Manitoba



Leith, Ordovician Schizocoralla from Manitoba

Pragnellia. It thus appears, as first suggested by Lindström, that the Protaraeinae of Kiär—the Coccoseridae of Lindström—should not be included in the Family Heliolitidae. The writer believes these corals should not be included in the Order Heliolitina of Okulitch and that a new order—the Protaraeina—should be erected for this group of corals which would include the Subfamily Protaraeinae of Kiär as a new family—the Protaraeidae. If *Coccoseris* is a valid genus the name Coccoseridae would have priority over Protaraeidae.

Because of the marked differences between the corals described here it may be that more than one order should be established. However, with the present available knowledge it does not seem advisable to do so. Perhaps more than one family should be erected but again the information is lacking. The striking differences between the Protaraeina and the other orders of the Schizocoralla suggest that they may not even belong to this subclass. If there is a bacular structure in the Heliolitidae, as stated by Lindström and Kiär, which the writer can not determine at the present time, then of course there is a relationship. It was with some hesitation that Okulitch (1936, p. 377) proposed the Subclass Schizocoralla to include aberrant families. Probably the Protaraeidae is another aberrant coral family which, for the present, is best classified with this subclass.

Class Anthozoa
Subclass Schizocoralla Okulitch, 1936
Order Protaraeina Leith, new order

Schizocoralla characterized by a bacular skeleton in which the corallites lack definite thecal walls. The outer edge of the corallites is defined by rod-like or irregularly shaped baculi similar to those in the coenenchyma. The coenenchyma is more or less abundant and often gives a papillate appearance to the surface of the corallum.

Family Protaraeidae Leith, new family

The Subfamily Protaraeinae Kiär formerly considered as belonging to the Family Heliolitidae, which has now been placed in the Order Heliolitina Okulitch, is elevated to family rank and placed with the Order Protaraeina.

Genus Protrochiscolithus Troedsson, 1929

In 1904 Kiär proposed *Protrochiscolithus* as a hypothetic genus in his subfamily Protaraeinae and he suggested that "Jedoch mag vielleicht *Heliolites* (?) *parasitica*, Nich. & Eth. zu diesem Typus gehören" (Kiär, 1904, p. 49). Lang, Smith and Thomas (1940, p. 107) listed and recognized *Protrochiscolithus* Kiär as a valid genus with the notation that the genotype, by author's original designation is *Heliolites* (?) *parasiticus* Nicholson and Etheridge. The writer, however, fails to see how Kiär's statement on *H.* (?) *parasiticus*, as given above, could possibly be interpreted as indicating a genotype for *Protrochiscolithus* Kiär. Furthermore, it is not possible to compare an object such as *H.* (?) *parasiticus* with a hypothetical form. Opinion 2 of the International Commission on Zoölogical Nomenclature very clearly states that names based on hypothetical forms have no status under the Code. Therefore *Protrochiscolithus* Kiär, proposed as a hypothetic genus is not a valid name. Troedsson (1929, p. 115) also credited the name *Protrochiscolithus* to Kiär and this is somewhat surprising as in his discussion of the subfamily Protaraeinae he stated that "In this family Kiaer included the primitive, *hypothetic* (italics mine)

Explanation of Plate 115

Figs. *1–6*—*Protrochiscolithus kiaeri* Troedsson. Polished and thin sections of part of a corallum, Lockport, Manitoba; Univ. Manitoba 116. *1–2*, Longitudinal polished section ×1 and ×4. *3*, Polished transverse section across corallites ×4. *4*, Transverse thin section across corallites to show nature of boundary between corallites ×8. Longitudinal thin section to show tabulae and indefinite bacular structure ×6½ and approx. ×10. (p. 792)

7–11—*Protaraea cutleri* Leith, n. sp.; Stony Mountain, Manitoba; holotype Univ. Manitoba 110. *7–8*, Surface and part of corallum ×1 and ×3. *9*, Longitudinal thin section showing shallow calix at upper edge ×6. *10*, Transverse thin section near surface of corallum ×6. *11*, Transverse thin section at or just below general level of the bases of the calices ×6. (p. 793)

genus *Protrochiscolithus*." However, Troedsson at that time gave a very detailed description of a species which he named *Protrochiscolithus kiaeri* and together with the illustrations of the species there can be no doubt as to the object he named. Thus *Protrochiscolithus* Troedsson, 1929, is a valid name for a genus and the genotype, by monotypy, is *P. kiaeri* Troedsson. *Protrochiscolithus* Kiär, 1904, as the name of a hypothetical form does not invalidate *Protrochiscolithus* Troedsson, 1929.[3]

PROTROCHISCOLITHUS KIAERI Troedsson
Plate 114, figures 1–9; plate 115, figures 1–6

Protrochiscolithus kiaeri TROEDSSON, 1929, Meddelelser Om Grønland, vol. 72, no. 1, p. 116, text-figure 2, pl. 30, pl. 46, figure 2.

This species, as identified here, is a very common one in the Selkirk member of the Red River formation at Lockport and Garson, Manitoba. It was first found by Troedsson in the Cape Calhoun beds at Cape Calhoun, northern Greenland. Because the writer interprets the internal structure somewhat differently than does Troedsson there is a possibility that the Manitoba specimens may not be the same species. *Protaraea vetusta* (?) var. *magna* Whiteaves found in the Selkirk member at Lower Fort Garry, about three miles north of Lockport, probably belongs to this species.

Superficially the coralla of this species resemble stromatoporoids and in the past they may have been mistaken for them. The corallum is large and grows as thick crusts on organisms such as corals, stromatoporoids and cephalopods. The largest corallum measured, which is roughly hemispherical in outline, is 90 mm. (3¾ inches) high with diameters of 190 mm. (7¼ inches) and 166 mm. (6½ inches). Another corallum with a diameter of 152 mm. (6 inches) has a height of 114 mm. (4½ inches). An incomplete specimen which encrusts a straight cephalopod is 227 mm. (9 inches) long, approximately 88 mm. (3½ inches) wide, and 37 mm. (1½ inches) thick. The lower surface in the majority of specimens is firmly attached to the object on which the corallum grew but in one specimen (fig. 9 on plate 114) there is a complete and well developed peritheca. On the upper surface the corallites which average about 2 mm. in diameter are closely crowded and rounded polygonal in outline. The calices are very shallow. There are 12 short, sharply pointed septa which reach the low columella at the centre of the calix.

As seen on the surface of the corallum (figures 2–3, plate 114), and on longitudinal and transverse polished sections (figures 2–3, plate 115) there appears to be a solid wall between the corallites. However, at greater magnification, in longitudinal and transverse thin sections (figures 4–6, plate 115) the entire corallum appears to be constructed of corallites separated from each other by only a thin coenenchyma. The entire skeleton is composed of baculi with some pores or tubes. In the longitudinal thin sections the spaces between the septa are white in color and the bacular structure can be detected by the herring-bone appearance of dark and light grey color. The transverse thin section shows the pores or ends of tubes and the interseptal spaces as white, and the light and dark grey areas represent the truncated ends of the baculi. No definite thecal wall between the corallites could be detected and each corallite shares with its adjacent corallites the structure just described. The columella is also composed of baculi with pores or tubes. In the corallites the dissepiments are abundant and closely spaced.

The description of the external features and the illustrations of both external and internal features as given by Troedsson for *P. kiaeri* suggests that our specimens are conspecific with the Greenland type. However, the writer interprets the internal features somewhat differently than does Troedsson for his specimen. Troedsson described the boundary between the corallites as an irregular external wall and he stated that "In longitudinal sections the original corallites are well preserved throughout the specimen, no baculi being developed between the corallites." From this description it might appear that the boundary between each corallite is a solid wall or plate-like

[3] Opinion 2, International Commission on Zoological Nomenclature, Pithecanthropus Haeckel, 1866, name of hypothetical genus, does not invalidate *Pithecanthropus* Dubois, 1894.

partition similar to the type found in the Heliolitidae. The writer, however, believes that there are no distinct corallite walls and that only a thin bacular coenenchyma separates the corallite tubes from one another.

Protaraea vetusta var. *magna* Whiteaves appears to be very similar to *Protrochiscolithus kiaeri*. Whiteaves referred *magna* with doubt to *P. vetusta* and stated that it perhaps should be a distinct species because it differed from *P. vetusta* chiefly in its much greater size and thickness. He also noted that it was very similar to *Protaraea ungerni* (Eichwald) but had slightly smaller calices. The similarity between *P. ungerni* and the specimens at hand is not apparent.

According to Troedsson *magna* differs from *P. vetusta* in forming larger and thicker crusts with wider corallites and he stated that in this respect it coincides fairly well with *Protrochiscolithus kiaeri*. He, however, remarked that the Manitoba form is probably identical with *P. ungerni*. In his discussion of these forms Troedsson (1929, p. 116) made the following observation:

> And the generic description (i.e. for *Protaraea*) given by Edwards & Haime was founded upon specimens formerly included with *P. vetusta* but now referred to *P. richmondensis*, as remarked by Foerste.[2] Furthermore the figures of the transverse and vertical sections of *Protaraea vetusta* given by Lambe[3] show quite a different interior structure; there are well defined corallites with 12 septa and an interspace with thin tubules but no trace of baculi. *Protaraea vetusta* forms thin crusts on strophomenids and other shells. It is urgent to study this form closer in order to decide whether it really belongs to the genus *Protaraea*. To judge from our present knowledge, it seems to be a representative of Kiaer's hypothetic genus *Protrochiscolithus*.

Troedsson also commented that *Protrochiscolithus* was similar to the central part of ramose specimens belonging to *Trochiscolithus* and though it is less bacular this structure is found in the whole colony. The thin intercellular tissue, large corallites, and thick and large crusts also distinguished *P. kiaeri* from *vetusta* which, as he stated (1929, p. 118), "seems to belong to the same genus." He commented also on the fact that other species of *Protaraea* differ by having the main part of the skeleton formed by strong baculi.

If *Protrochiscolithus*, as pointed out by Troedsson, is bacular throughout then it seems that the Manitoba forms under consideration are conspecific with *P. kiaeri*.

The writer sent a specimen which he identified as *P. kiaeri* to Dr. Alice Wilson of the Geological Survey of Canada for comparison with the type of *P. vetusta* var. *magna*. He is very greatly indebted to her for making the comparison, commenting on the specimens and information on *Protaraea vetusta*. She writes as follows:

> It (the specimen) looks exactly like the specimens of the type material externally . . . .
>
> Troedsson's illustration of the vertical section of *P. kiaeri* is not satifactory for the vertical section of the type of *P. vetusta magna*. Troedsson's illustration shows but a few straggling indications of dissepiments (writer's comment: Troedsson stated in his description that the interior space of the corallites has closely set tabulae, 0.08 mm. distant well visible in all sections). They are very pronounced in *P. vetusta magna*.
>
> I would also say that Lambe's drawing (Pal. Foss. 3, pl. 18, fig. 3) is inadequate. It also gives very little idea of the dissepiments. His drawing of *P. vetusta* from the Trenton of Ottawa (Con. Can. Pal. IV, pl. 5, fig. 8a) is much more like it, though of course there are not as many interspaces in *P. vetusta magna*. In fact an examination of a polished surface of *P. vetusta* itself shows that there are not nearly so many intertubular spaces even in it as represented by Lambe.
>
> The nature of the central columella or pseudocolumella is not very clear. Intertubular spaces are scarce. They also are indefinite but appear to have a few irregularly placed diaphragms.

A diagram, included in the letter, of the vertical section and part of the upper surface suggests that our material is the same form as Whiteaves type.

The evidence given above very strongly suggests that Whiteaves *P. magna*, and the specimens described and illustrated in this paper, belong to *Protrochiscolithus kiaeri*. It must be remembered, however, that thin sections of *P. magna* are not available for a study of the nature of the boundary between the corallites and that Troedsson described corallite walls for *P. kiaeri*. For the present the writer feels that nothing would be gained by erecting a new species, or even a new genus, for the type of schizocoral described.

PROTARAEA CUTLERI Leith, n. sp.
Plate 115, figures 7–11

The corallum is small and forms thin crusts up to 1.5 mm. in thickness on shells. Diameter of the largest corallum examined is 17 mm. The corallites are small, closely

set, number four in a distance of 5 mm. and are not separated from the coenenchyma by a definite wall. Calices are very shallow. Densely packed baculi form the skeleton and their upper ends give a papillate appearance to the surface of the coenenchyma and bottoms of the calices; specimens available for study show effects of weathering but the papillate structure is believed to be original. The septa, where observed on the surface of the corallum, are short, triangular in outline and number 12 but in the majority of the calices they can not be distinguished from the papillae. As there are no definite corallite walls and the septa often resemble the papillae, it is not always possible to determine the exact limits of any one corallite.

In longitudinal sections no trace of a thecal wall between the corallites and coenenchyma could be detected. The position of a corallite is indicated only by the shallow indentation of its calix because the baculi of the corallite, including the ones that form the septa, are similar to those making up the coenenchyma. The baculi in thin section have, as pointed out by Lindström, a pinnate appearance with very fine fibrillae directed upwards from a central axis which appears as a white line in some of the baculi. According to Lindström this white line has no significance.

In transverse sections the septa appear to be distinct in some of the calices, rather indefinite in others and they vary considerably in outline with many of them appearing as short sharp projections around the edge of the corallite. Baculi in the coenenchyma are square, hexagonal or irregular in outline. The outer parts of the septa are shaped so that they fit tightly against the baculi and appear to form an integral part of the coenenchyma. The septa are probably baculi which form the outer margin of the corallite. Baculi were also observed at the center of the corallites.

This species resembles *Protaraea richmondensis* var. *papillata* Foerste, but has smaller and less distinctly marked off corallites with a wider zone of coenenchyma surrounding the corallites. The papillae are smaller in this species and appear to be more numerous.

P. cutleri is very rare in the Stony Mountain formation, Stony Mountain, Manitoba. It has been found in the Penitentiary and Stony Mountain members. Whiteaves (1894, 1897) reported, without describing or illustrating, a specimen of *P. vetusta* Hall from the Stony Mountain and one from the Dog Head member of the Red River formation on Little Black Island, Lake Winnipeg. In all probability the specimens which Whiteaves identified as *P. vetusta* are conspecific with this new species rather than with *P. richmondensis* Foerste as cited in Bassler's *Bibliographic Index of American Ordovician and Silurian Fossils.*

The species is named for W. E. Cutler who, in 1922, and 1923, assembled a very large collection of fossils from the beds exposed at Stony Mountain. The material which is now part of the University of Manitoba Collections contains only eight specimens and a mold of the species. A specimen collected in 1942 by H. Rand, Keeper at the Manitoba Museum, has been, to the writer's knowledge, the only specimen of this species found since 1923.

Genus PRAGNELLIA Leith, new genus
Plate 116, figures 1–8

This new genus, represented by one new species *Pragnellia arborescens*, the genoholotype, is based on a single, unique, very large arborescent corallum. The branches of the corallum divide regularly, taper gradually and are composed of alternate nodes and internodes. Their cross section is circular to subovate. The coenenchyma is composed of many loosely packed rods which are held gether by irregularly arranged cross-bars. The upper ends of the rods appear as papillae on the surface of the corallum. The corallites are small, circular in cross section separated from each other by a moderately wide coenenchymal zone and they lack distinct thecal walls. The outer margin of each corallite is formed by a single row of closely arranged rods which are identical with the rods in the coenenchyma.

Arborescent varieties of schizocorals are not very common. In addition to the new genus described here examples of this type of growth include *Heliolites barrandei* var. *spongodes* Lindström, *Diploëpora ramosa* (Kiär), *D. grayi* (Milne-Edwards and Haime), *Trochiscolithus micraster* (Lind-

ström), and *Porites inordinatus* Lonsdale. In these the branches are not so regularly formed nor divided into nodes and internodes as in *Pragnellia*. The alternate nodes and internodes of the branches in *Pragnellia* are very distinctive of this genus and to the writer's knowledge this type of structure has not been recorded previously for Paleozoic corals. The loosely packed rods in the coenenchyma and the single row of rods surrounding each corallite are also characteristic features of this new genus.

This genus is named in honor of Mr. R. Pragnell of St. Vital, Manitoba who collected the specimen on which the genus is founded. He very kindly presented the specimen to the Manitoba Museum. The writer is indebted to the officers of the Manitoba Museum for permission to describe and illustrate the specimen.

PRAGNELLIA ARBORESCENS
Leith, new species
Plate 116, figures 1–8

This new species is based on a single specimen of a corallum which is incomplete at the top and probably at the base. The specimen was found on a bedding plane and from the uniform position of the branches and direction of growth it appears that the original form of the corallum is preserved. Also the undisturbed position of the nodes and internodes of the branches indicates that very little disturbance of the specimen occurred after the death of the coral.

The corallum is large and arborescent with a height of 258 mm. (10^+ inches) and a maximum width or lateral spread near the top of 184 mm. (7.3^- inches). Four main branches arise from a short, basal, trunk-like part 30 mm. in length and 37 mm. in diameter, which probably is not the actual base of the corallum. It is quite possible that the specimen might be only the remains of a much larger and more branched corallum. The branches divide regularly, almost dichotomously, taper gradually, and their cross section is nearly circular in the smaller branches and subovate in the larger or main branches. The diameters near the base of a branch with a subovate section are 21 mm. and 17 mm., and in a distance of 125 mm. towards the tip the diameters are reduced to 19 mm. and 15 mm. respectively. The branches and basal trunk-like part are divided into alternate nodes and internodes. The internode segments range in length from 4 mm. to 34 mm., and the nodes average about 3 mm. in length and rarely exceed a length of 10 mm. The internodes are constricted near their centers so that they superficially resemble phalanges. The ends of the internodes are marked by closely spaced, concentrically arranged lines and wrinkles crossed by radially arranged wrinkles.

The corallites are circular in outline, small, average 1 mm. in diameter and are distantly spaced, numbering three or rarely four in a distance of 5 mm. They are not separated from the coenenchyma by definite walls. No septa were observed. The surface of the coenenchyma is papillate. At the edges of a few of the corallites the papillae resemble short septa.

The coenenchyma consists of numerous, loosely packed rods which are held together by irregularly spaced cross-bars. The rods are arranged at right angles to the internode surface and radiate from the long axis of the internode or they diverge outwards from the sides of the corallites. As seen in transverse sections the sides of the rods have very small, barb-like structures or small, sharply pointed triangular projections. Unfortunately the structure of the material composing the rods could not be determined. It is believed that they represent baculi.

Each corallite tube is surrounded by a single row of closely spaced rods which are similar to, but slightly thicker than, those in the main part of the coenenchyma. Material which appears to be similar to that in the rods, but may be secondary, fills in a large part of each corallite tube as an irregular plug-like body composed of thin, different sized, concave upwards, disk-like segments. The center in some parts of this plug-like body appears to be solid.

The distinctive features of this species are the arborescent corallum with regularly dividing branches composed of alternate nodes and internodes, coenenchyma of loosely packed rods and the single row of rods surrounding each corallite tube.

The most unusual and peculiar segmentation into nodes and internodes is not the re-

sult of breakage of the corallum after the death of the coral or during fossilization, for the ends of the internodes do not have a jagged surface and the nodes do not cut across the corallite openings. The surface of a tip of a branch which was accidentally broken during the preparation of the specimen is strikingly different from the internode end with its lines and wrinkles. The segmented appearance is considered to be an original characteristic feature and represents the formation of branches with alternate nodes and calcareous internodes. A horny substance, or even soft tissue, neither type capable of preservation probably formed the nodes. The material now occupying the node is composed of shale.

It is interesting, as a speculation, to compare the corallum of this species with that of the present day alcyonarian coral *Isis hippuris* Linnaeus which is found in shallow water localities in the West Indies, and Pacific and Indian Oceans. Branches in this species, 10 mm. and less in diameter, consist of alternate horny nodes and calcareous internodes, and they bend in any direction without breaking "for by bending freely to and fro with these soft joints they easily resist the violent motions of the sea."[4] The segmentation of the branches in *Pragnellia* seems to indicate that, just as in *Isis*, the branches could bend in any direction without breaking.

This species was found in the Stony Mountain member of the Stony Mountain formation, Stony Mountain, Manitoba.

[4] John Ellis, quoted by S. J. Hickson in An Introduction to the Study of Corals, 1924, p. 121.

The holotype, number 429^{P}, is in the collections of the Manitoba Museum.

ACKNOWLEDGMENT

Part of the cost of publishing the illustrations for this article is borne by the President's Research Fund, University of Manitoba.

REFERENCES

KIÄR, J., 1904, Revision der Mittelsilurischen Heliolithiden und neue Beiträge zur Stammesgeschichte derselben: Vidensk.-Selsk. Skr. 1 Mat.-naturv. Kl., no. 10, Christiania.

LANG, W. D., SMITH, S., and THOMAS, H. D., 1940, Index of Palaeozoic coral genera: British Museum, p. 38, p. 105.

LEITH, E. I., 1944, *Halysites gracilis* from the Ordovician of Manitoba: Jour. Paleontology, vol. 18, p. 268.

LINDSTRÖM, G., 1899, Remarks on the Heliolitidae: Kongl. Svenska Vetensk.-Akad. Handl., vol. 32, no. 1.

——, 1899, Die Korallenfaunen der Etage 5 des norwegischen Silursystem von Johan Kiär: Geol. Fören. Förh., vol. 21, no. 193, pt. 4, pp. 374–378.

OKULITCH, V. J., 1936, On the genera *Heliolites*, *Tetradium* and *Chaetetes:* Amer. Jour. Sci., vol. 32, 5th ser., pp. 361–379.

TROEDSSON, G. T., 1929, On the Middle and Upper Ordovician faunas of northern Greenland. Part II: Meddelelser om Grønland, vol. 72, pp. 115–118.

TWENHOFEL, W. H., 1928, Geology of Anticosti Island: Geol. Surv. Canada, Mem. 154, p. 67.

WHITEAVES, J. F., 1897, The fossils of the Galena-Trenton and Black River formations of Lake Winnipeg and its vicinity; Geol. Surv. Canada, Palaeozoic Fossils, vol. 3, pt. 3, pp. 155–165.

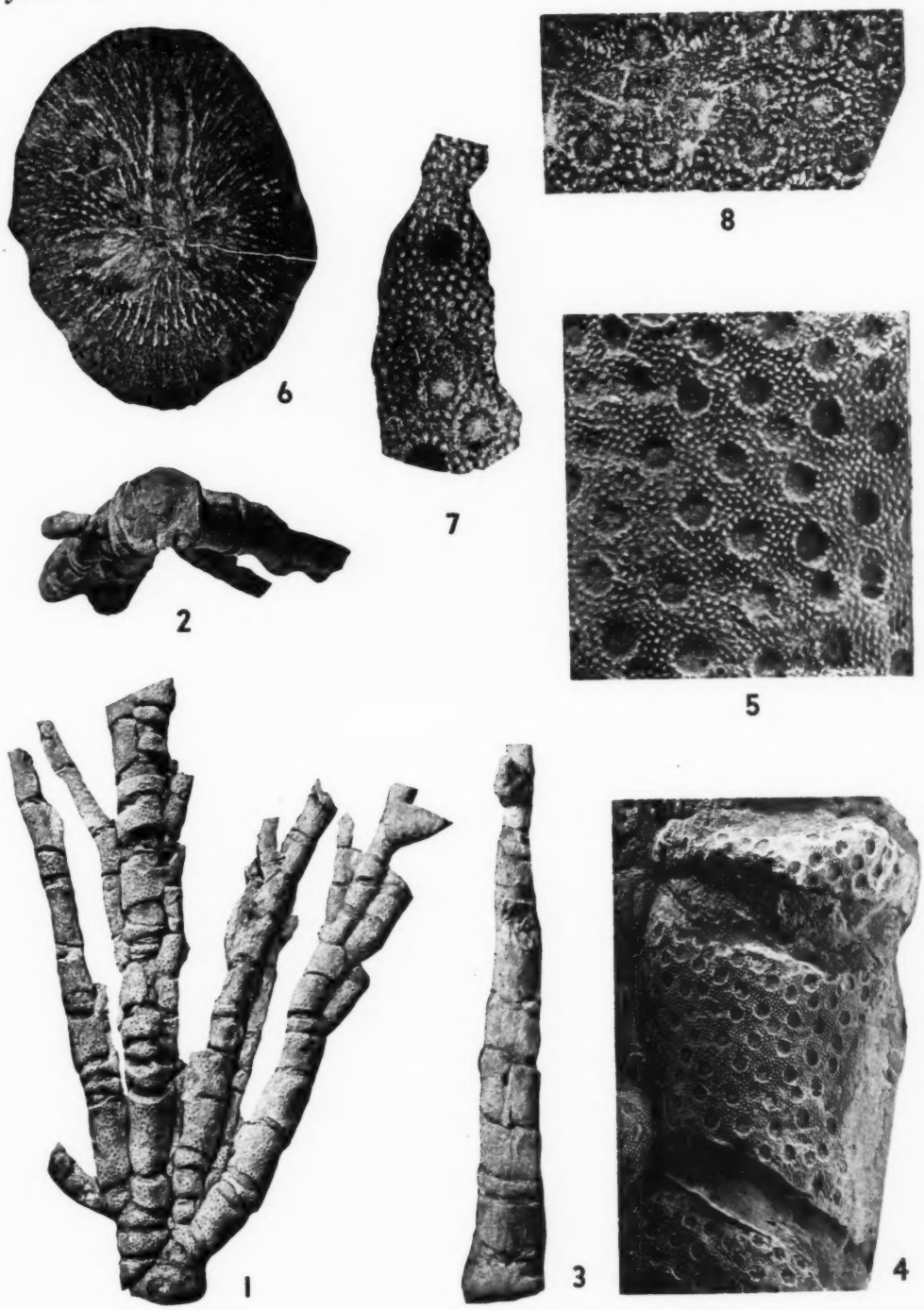
ZITTEL-BROILI, 1924, Grundzüge der Paläontologie, Ab. 1, pp. 131–133.

ZITTEL-EASTMAN, 1913, Text-book of paleontology, vol. 1, pp. 111–112.

EXPLANATION OF PLATE 116

FIGS. *1–8*—*Pragnellia arborescens* Leith, n. gen., n. sp., Stony Mountain, Manitoba; holotype, Manitoba Museum Association 429^{P}. *1–3*, Side and tilted basal views of corallum, and side view of the branch at right side of corallum ×¾. *4*, Part of branch to show nodes, internodes and surface ×2. *5*, Detail of surface ×5. *6*, Transverse thin section of a branch ×5. *7*, Thin section close to surface ×5. *8*, Thin section of area at or just below general level of bases of calices ×5.

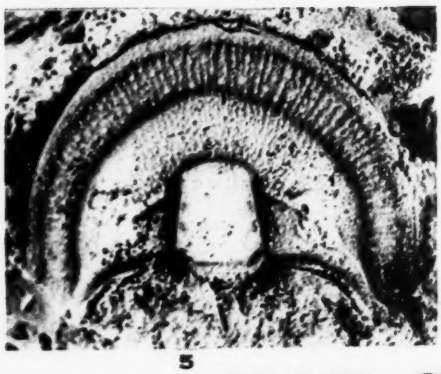
(p. 794)



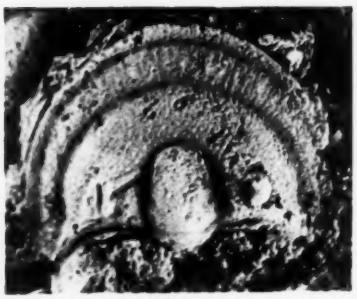
Leith, Ordovician Schizocoralla from Manitoba

1

4



5



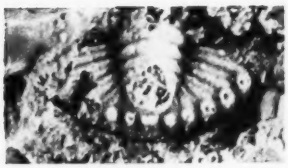
2

3

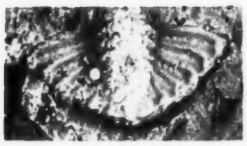
6

7

8

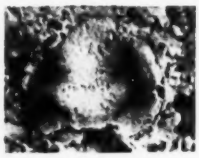


9



12

10



11

13

Rasetti, Cephalic sutures of *Entomaspis*

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 797–802, PL. 117, 5 TEXT FIGS., SEPTEMBER 1952

CEPHALIC SUTURES IN THE UPPER CAMBRIAN TRILOBITE *ENTOMASPIS*

FRANCO RASETTI
Johns Hopkins University, Baltimore, Maryland

ABSTRACT—*Entomaspis radiatus* possesses dorsal facial sutures of the opisthoparian type, both the anterior and posterior branches running outward and backward, extremely close to each other, delimiting slender ocular platforms. Analogous sutures were recently described in the Lower Ordovician genus *Hypothetica*. A new species of *Entomaspis* is described. The possibility of *Entomaspis* being ancestral to the Trinucleidae is discussed.

THROUGH the courtesy of Dr. Josiah Bridge, the writer had the opportunity to study the Ulrich collection of trilobites from the Eminence dolomite of Missouri, including the only material of the rare genus *Entomaspis* ever brought to light. It immediately appeared, from observation of specimens better preserved than the types, that the cephalic sutures of *Entomaspis radiatus* had been misinterpreted by Ulrich (in Bridge, 1930). Since *Entomaspis* proves to possess sutures of an exceptional type, so far known only in *Hypothetica rawi*, a redescription of this trilobite is deemed opportune. A new species of *Entomaspis*, based on a pygidium, is also described.

Genus ENTOMASPIS Ulrich in Bridge, 1930

Description.—Aberrant Ptychopariidae with both branches of the facial suture running outward and backward. Cephalon semicircular, considerably convex as a whole. Glabella occupying about one-half the cephalic length, slightly tapered, subtruncated in front, elevated above the fixed cheeks. Glabellar furrows weak, occipital furrow well impressed. Fixed cheeks and brim convex, downsloping; marginal furrow impressed, rim wide. Ocular ridges strong; palpebral lobes short, elevated, well defined by the palpebral furrow, situated at the level of the glabellar midpoint and distant from the glabella somewhat more than half the glabellar width. Anterior branch of facial suture strongly curving backward immediately after leaving the anterior end of the palpebral lobe, directed outward and backward for most of its dorsal course, parallel and very close to the posterior branch; at its posteriormost point reaching farther back than the posterior margin of the occipital ring; then curving outward and forward, reaching the cephalic margin and remaining marginal to the median line. Posterior branch with sigmoid curvature, reaching the posterior margin just inside of

EXPLANATION OF PLATE 117

FIGS. *1–11*—*Entomaspis radiatus* Ulrich in Bridge. *1*, left dorsolateral view of internal cast of cranidium, ×15, showing facial sutures; USNM 116608a, plesiotype (loc. 373L). *2*, *3*, Dorsal and lateral views of same specimen, ×8. *4*, Right dorsolateral view of internal cast of cranidium, ×15, showing facial sutures; USNM 116608b, plesiotype (loc. 373L). *5*, Dorsal view of same specimen, ×8. *6*, Impression of lower (external) surface of free cheek, ×5; USNM 83498, syntype (loc. 455v). *7*, Impression of upper surface of free cheek, ×5; USNM 116608c, plesiotype (loc. 373L). *8*, Impression of lower surface of free cheeks, ×5; USNM 116609a, plesiotype (loc. 452u). *9*, Internal cast of pygidium, ×12; USNM 116609c, plesiotype (loc. 452u). *10*, Internal cast of pygidium, ×8; USNM 116609b, plesiotype (loc. 452u). *11*, Hypostoma, ×12; USNM 116609d, plesiotype (loc. 452u). (p. 798)

12—*Entomaspis trigonalis* Ulrich in Bridge. Internal cast of pygidium, ×8; USNM 83495, holotype (loc. 238h). (p. 799)

13—*Entomaspis bridgei* Rasetti, n. sp. Internal cast of pygidium, ×12; USNM 11610, holotype (loc. 455v). (p. 799)

All specimens are from the Eminence dolomite of the Ozark region, Missouri. For description of localities see text.

the base of the genal spine. Posterior limbs slender, strongly curved backward, deeply furrowed, reaching but a little farther back than the anterior limb. Free cheeks united into a single piece. Anterior part consisting of doublure, extending under the rim and also for some distance under the brim, furrowed in correspondence with the marginal furrow on the dorsal shield. Pleural platforms reduced to almost vanishing width where the two branches of the facial suture come close together, wider around the eyes. Genal spines strong.

Thorax unknown. Pygidium wide and short, subtriangular, with annulated axis, flat, straightly furrowed pleural lobes, and a vertical posterior slope. Surface of brim and rim with irregular radial furrows; shields ornamented with granules and tubercles of various sizes.

Genotype.—Entomaspis radiatus Ulrich in Bridge.

Stratigraphic and geographic range.—Upper Cambrian (late Trempealeauan; Eminence dolomite) of the Ozark region, Missouri.

ENTOMASPIS RADIATUS Ulrich in Bridge
Plate 117, figures 1–11; text figures 1–3

Entomaspis radiatus ULRICH in Bridge, 1930, Geology of the Eminence and Cardareva quadrangles. Missouri Bur. Geol. Mines, vol. 24, 2nd ser., p. 213, pl. 19, figs. 14–16.

Available material.—The type lot includes as syntypes one cranidium, one free cheek and one pygidium. The entire collection contains about a score of cranidia, a few free cheeks, two hypostomas, and a dozen pygidia. All the material is preserved in form of external or internal impressions in chert resulting from alteration of the Eminence dolomite. Most of the cranidia and pygidia are preserved as internal casts, hence the description is based on the appearance of the lower surface.

Description.—To avoid repetition, characters included in the generic description are not mentioned.

Glabellar length about $\frac{4}{5}$ of width at the base. Occipital ring short, apparently simple, although one specimen in the collection shows a small, slender occipital spine; this is more likely to represent a different species or an aberrant individual. Three pairs of glabellar furrows, all very shallow, visible only at the sides. Occipital furrow deep at the sides, narrower and shallower in the straight median portion. Midlengths of brim and rim equal, the entire frontal limb slightly exceeding the glabella plus occipital ring in midlength. There are two furrows paralleling the anterior and lateral cephalic margin, the deeper one, closer to the glabella, marked by a considerable change in slope of the cranidial surface; the other, shallower furrow is close to the margin. The writer interprets the first as the marginal furrow, and the area in front of it as the rim. Palpebral lobes about $\frac{1}{4}$ the glabellar length, strongly curved and elevated. Posterior marginal furrow deep, especially in the proximal portion.

Free cheeks consisting of one piece, as shown by one fragment (Pl. 117, fig. 8) which extends on both sides of the midline. Anterior part of free cheeks consisting of doublure under rim and brim, furrowed in correspondence with the marginal furrow on the cranidium. Pleural platforms and eyes not preserved in any of the specimens; their shape has been inferred (text fig. 3) from the course of the sutures on the cranidium. Genal spines strong, about twice the glabellar length.

Ornamentation of cephalon as shown on internal impressions consisting of granules on fixed cheeks, brim and rim, radially arranged on the brim and, more distinctly, on the rim, where they are separated by fairly regular radial furrows. Portion of rim outside of outermost furrow smooth. Doublure of free cheeks with same radial furrows as rim; genal spines smooth.

Hypostoma tentatively attributed to the species subtrapezoidal, widened posteriorly, about $1\frac{1}{2}$ times wider than long. Anterior margin straight, anterior wings small, extending but little beyond the lateral outline of the shield; lateral margin almost straight, posterior angles rounded, posterior margin not well preserved. Two pairs of deep depressions, the posterior ones more widely spaced than the first pair, oblique, directed inward and backward; all these depressions are confluent with a wide, rather

undefined marginal furrow. Lateral margin elevated.

Pygidium subtriangular, about three times wider than long; axis tapered, prominent, composed of five rings and a terminal section, almost reaching the posterior margin. Ring furrows well impressed. Pleural lobes horizontal, with five pairs of pleural furrows and four pairs of shallower interpleural grooves; without distinct marginal furrow. Rim forming a steep, almost vertical slope. Axis with a pair of tubercles on each ring. On the first two pleura there is a small tubercle. Posterior margin marked by 11 to 13 large, prominent tubercles. In some specimens, these tubercles appear hollow and broken on casts of the inner surface, and it is possible that, when complete, they represented vertical spines.

Formation and localities.—Eminence dolomite. The type localities are (as numbered by Ulrich):

453L: 3 miles east of Potosi, Missouri.

455v: chert near top of Eminence dolomite, near top of south slope of hill 4¾ to 5 miles south of Potosi, Missouri.

The species is also present in collections from the following localities:

373L: 15–30 feet below top of Eminence dolomite; 1 mile northwest of Eminence, Missouri.

452u: road cut 3 miles south of Eminence on highway to Winona, Missouri.

Types.—Syntypes: USNM 83497–8. Plesiotypes: USNM 116608–9.

Discussion.—The cephalic sutures of this trilobite are so peculiar, that they were misinterpreted even by such an acute observer as Ulrich, who wrote:

> The anterior half of the facial suture is generally completely obliterated in the fusion of the cheeks, but a thin ridge that I regard as representing their fused edges behind each eye is commonly clearly notable. It runs with gently sigmoid curvature from the eye to a point opposite the inner half of the wide base of the genal spine.

In his restoration (Pl. 19, fig. 14) he shows such a line, starting from the posterior end of the palpebral lobe. This is the approximate course of the posterior branch of the facial suture, but he failed to see that there was also an anterior branch, paralleling the other and rounding off the posterior extensions of the rim. The presence of both branches of the facial suture can be seen in about a dozen specimens where the relevant part of the cranidium is sufficiently well preserved. On the two cranidia illustrated in this paper, the sutures are more clearly visible than in the type cranidium. As it is difficult clearly to show these features on reproductions of photographs, restorations of the cranidium, pygidium and free cheeks are presented (text figs. 1–3).

ENTOMASPIS TRIGONALIS Ulrich in Bridge
Plate 117, figure 12

Entomaspis trigonalis ULRICH in Bridge, 1930, Geology of the Eminence and Cardareva quadrangles. Missouri Bur. Geol. Mines, vol. 24 2nd ser., p. 214, pl. 19, fig. 17 (12, 13 ?).

Available material.—An internal cast of a pygidium in chert is the holotype. An impression of a cranidium was tentatively assigned to the species as paratype.

Description.—Ulrich's original description of the holotype follows:

> The species is founded mainly on a pygidium. Its appearance in general is much the same as the pygidium referred to *Entomaspis radiatus* but differs in its relatively greater length, more triangular outline, and proportionately smaller though equally numerous marginal knobs. The pleural segments also are more deeply grooved and comprise an extra short posterior pair. Its length is 1.8 millimeters, width 3.6 millimeters.

Ulrich considered an associated cranidium slightly different from *E. radiatus*, but the preservation seems too poor to establish such differences, and furthermore, there is no certainty that the two fragments belong to the same species.

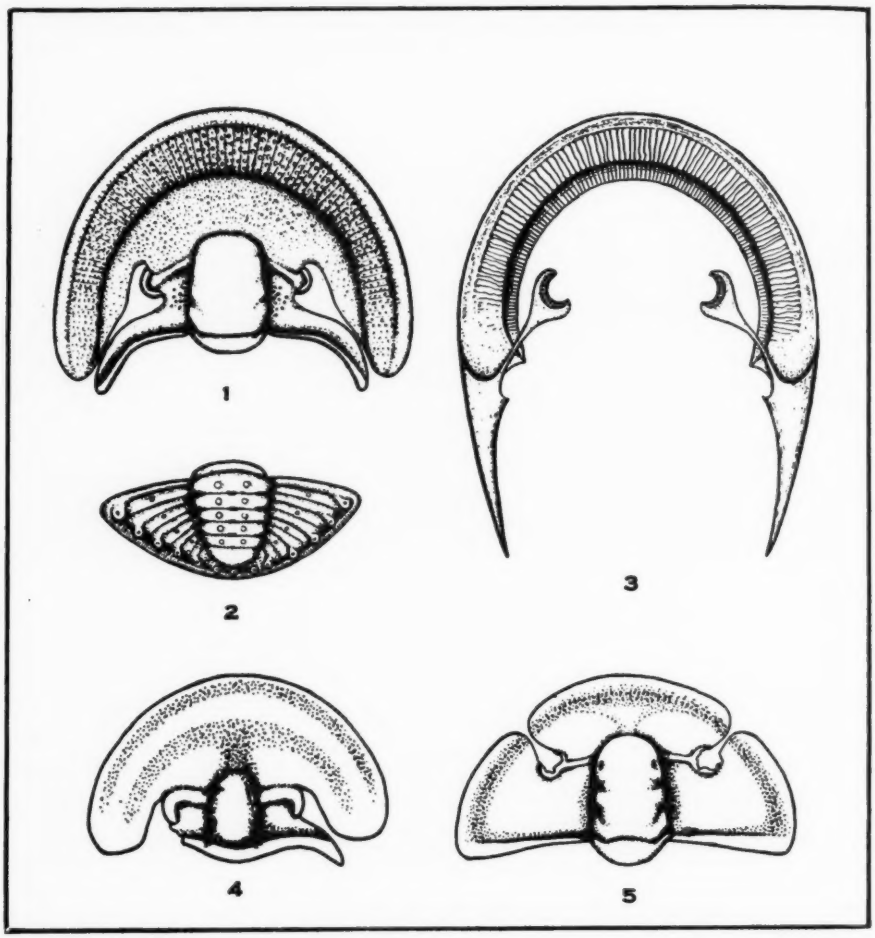
Horizon and locality.—Eminence dolomite; type locality 238h: 1 mile east of Berryman, Missouri.

Types.—Holotype: USNM 83495. Paratype: USNM 83496.

ENTOMASPIS BRIDGEI Rasetti, n. sp.
Plate 117, figure 13

Available material.—One internal cast of a pygidium.

Description.—Pygidium subtriangular, about 3 times wider than long; the exact proportions cannot be ascertained because



FIGS. *1–3*—*Entomaspis radiatus* Ulrich in Bridge. *1*, Cranidium, ×8. *2*, Pygidium, ×8. *3*, Restoration of free cheeks, ×8. (p. 798)
4—*Hypothetica rawi* Ross. Holotype cranidium, ×16. (p. 801)
5—*Loganopeltoides kindlei* Rasetti. Cranidium, ×6. (p. 801)

the anterior angles are not completely preserved on either side. Axis more strongly tapered than in *E. radiatus*, almost reaching the posterior margin, with about four not very distinct rings and a terminal section. Pleural lobes horizontal, furrowed over the entire area of the pleural platforms. Four pairs of well-impressed, straight pleural furrows plus a short, less distinct fifth pair, separated by shallower and narrower, but distinct interpleural grooves. Posterior margin of pygidium slightly raised to a narrow ridge, followed by a vertical face. Surface ornamentation not apparent from the cast of the lower surface. Length of pygidium 1 mm., width approximately 3 mm.

Horizon and locality.—Chert near top of Eminence dolomite. Locality 455v: near top of south slope of hill 4¾ to 5 miles south of Potosi, Missouri.

Type.—Holotype: USNM 116610.

Discussion.—This pygidium was found in association with *Entomaspis radiatus*, a few, small cranidia of an undescribed species of *Entomaspis*, and one pygidium evidently belonging to the genus but different from

either *E. radiatus* or *E. trigonalis*. The associated cranidia may belong to the present species, which is described, in spite of the very meager material, because of the remarkable similarity to the pygidia of the Trinucleidae.

RELATIONSHIP OF *ENTOMASPIS* TO OTHER TRILOBITES

There is only one other described trilobite whose sutures have the same course as in *Entomaspis radiatus*. This is *Hypothetica rawi*, recently described by Ross (1951) from the Garden City formation (Lower Ordovician) of Utah. To facilitate a comparison, a drawing of the type cranidium of *Hypothetica rawi* is presented, together with restorations of the cranidium, pygidium and free cheeks of *Entomaspis radiatus* (text figs. 1–4). The chief differences between the cranidia of the two species are the greater over-all convexity of *Entomaspis*, presence of a well-impressed anterior marginal furrow, different course of the ocular ridges, and extension of the dorsal furrows to the posterior margin of the cephalon. It is also possible that the pygidium of *Hypothetica* is similar to those of *Entomaspis*, as one might be tempted to assign to *Hypothetica rawi* a pygidium from the same locality and horizon, figured by Ross (Pl. 19, figs. 32, 33). In any case, the writer believes that the cephalic characters alone justify reference of *Hypothetica* to the family Entomaspidae.

Some resemblance also exists between the cephala of *Entomaspis* and *Loganopeltoides* (Rasetti, 1945, 1948), especially in the shape of the glabella, and close parallelism between anterior and posterior branches of the facial sutures. However, in *Loganopeltoides* both branches are directed outward and forward (see for comparison a drawing of the cranidium of *Loganopeltoides kindlei* Rasetti, text fig. 5). Furthermore, the pygidia of *Loganopeltoides* have an entirely different shape from those of *Entomaspis;* and while *Entomaspis*, in view of the relative proportions of cephalon and pygidium, probably had a thorax of few segments, *Loganopeltoides*, in analogy with the closely related *Loganopeltis* (Rasetti, 1943) must have had a thorax of about 20 segments. All these differences suggest that *Loganopeltoides* and *Loganopeltis* are not as closely related to *Entomaspis* as to the Ordovician genus *Harpides*, as remarked by Raw (1950)[1] and Whittington (1950). In this connection, it should be mentioned that *Entomaspis clarki*, described by Raymond (1937) cannot be assigned to that genus, as it has no dorsal sutures. It probably belongs to *Harpides*, a reference tentatively suggested by Raymond himself. A similar or identical form occurs in the boulders of the Lévis conglomerate, in association with *Leiostegium* and other Canadian fossils. Removal of Raymond's species leaves *Entomaspis* confined to the Eminence dolomite of Missouri.

A possibility worth considering is that *Entomaspis* is on or or close to the ancestral line of the Trinucleidae. The writer believes that *Entomaspis*, like *Hypothetica* and *Loganopeltoides*, was on the way of becoming a "hypoparian" trilobite (in the last case, we fortunately know the corresponding "hypoparian" form, the Lower Ordovician *Loganopeltis*). Complete fusion of the anterior and posterior branches of the facial suture in *Entomaspis* would leave precisely the type of cephalic suture observed in the Trinucleidae, with the free cheeks forming the "lower lamella" and carrying the genal spines. The pydigia of *Entomaspis* and the Trinucleidae are strikingly similar. However, only the discovery of intermediate forms in the Lower Ordovician could definitely substantiate this hypothesis.

REFERENCES

BRIDGE, JOSIAH, 1930, Geology of the Eminence and Cardareva quadrangles: Missouri Bur. Geol Mines, vol. 24, 2nd ser.; descriptions of Trilobita, credited to E. O. Ulrich, pp. 212–222, pls. 19, 21.

RASETTI, F., 1943, New Lower Ordovician trilobites from Lévis, Quebec: Jour. Paleontology, vol. 17, pp. 101–104, pl. 19.

——, 1945, Evolution of the facial sutures in

[1] Raw criticized the writer's interpretation of *Loganopeltoides*, suggesting that the lines described as sutures are accidental cracks of the test. Apparently Dr. Raw formulated these objections without ever having seen a specimen of these trilobites. In the writer's opinion, the reality of the described sutures cannot be doubted by anyone who is familiar with these fossils and their manner of preservation.

the trilobites *Loganopeltoides* and *Loganopeltis:* Amer. Jour. Sci., vol. 243, pp. 44–50, pl. 1.

——, 1948, Cephalic sutures in *Loganopeltoides* and the origin of "hypoparian" trilobites: Jour. Paleontology, vol. 22, pp. 25–29, pl. 7.

RAW, F., 1950, Facial sutures in the (hypoparian) trilobites *Loganopeltoides* and *Loganopeltis* and the validity of these genera: Jour. Paleontology, vol. 23, pp. 510–514, pl. 83.

RAYMOND, P. E., 1937, Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont: Geol. Soc. Amer. Bull., vol. 48, pp. 1079–1146, pls. 1–4.

WHITTINGTON, H. B., 1950, Swedish Lower Ordovician Harpidae and the genus *Harpides:* Geol. Fören. Förhandl., vol. 72, pp. 301–306, pl. 1

MANUSCRIPT RECEIVED JANUARY 2, 1952

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 803–817, PLS. 118, 119, 15 TEXT FIGS., SEPTEMBER 1952

REVISION OF THE PELECYPOD GENUS *ECHINOCHAMA*[1]

DAVID NICOL
U. S. National Museum

ABSTRACT—*Echinochama* is a tropical American, marine pelecypod which appeared in the early Miocene. It most likely arose from *Pseudochama draconis* (Dall) in the region around Florida. One new species, *Echinochama collinsi*, and one new subspecies, *Echinochama arcinella olssoni*, are described.

INTRODUCTION

ECHINOCHAMA is a relatively young genus which appeared suddenly in early Miocene time but was not well represented until middle Miocene time. Its exact place of origin is at present unknown, but some evidence points to the Florida region. The history of *Echinochama* is intimately related to the geologic history of the southeastern United States, the Caribbean, the Gulf of Mexico, Central America, and northern South America. The genus is at present poorly developed in the Panamic Province, a fact that is difficult to explain; otherwise, however, this successful newcomer has spread as far as temperature barriers and shallow water will allow.

Although various species of *Echinochama* have been studied by a great number of paleontologists and malacologists, no thorough work has been done on the entire genus. Dall (1903, pp. 1404–1406) has discussed some of the fossil and living species of *Echinochama*. Odhner (1919, pp. 32–37) has made a thorough study of the anatomy of one species, and some remarks on shell morphology are scattered throughout his monograph. Maury (1925, p. 287) has supplied some information on the stratigraphic and geographic range of *Echinochama* as well as a few generalized statements on the evolution of the genus. Many other workers have briefly discussed the morphological relationships and differences among the species and subspecies.

Although it is not within the scope of this paper to show the ancestry of the Chamidae, the following observations are noteworthy. Douvillé (1912, p. 454) has stated that the Chamidae were derived from the Lucinidae during the late Cretaceous. It is interesting to note that the living chamids and lucinids show three striking similarities in morphology. The first one is the posterior groove on the exterior of the shell which runs from the umbonal area to the posteroventral margin. This is well marked on many specimens of *Echinochama*. The second is the elongation of the anterior adductor muscle scar in *Echinochama*, and many other chamids, and a less pronounced elongation of the posterior adductor muscle scar as well. Thirdly, on a few species of chamids and on many lucinids, the pallial line passes in front to the ventral end of the anterior adductor muscle scar and joins it somewhere along the anterior margin.

This study has shown me that little is known about the relationships of species in a comparatively well known genus. New species have been proposed mainly in faunal monographs; they have been deemed new because they occur in different geographic provinces or in different stratigraphic zones. I feel that the primary basis of differentiation should be shell morphology, with differences of geography and stratigraphy used only as adjuncts.

Although the main divisions of tropical American stratigraphy are generally agreed upon, the exact correlations of many formations are not. As an example, Cooke, Gardner, and Woodring (1943) consider the Bowden formation of Jamaica to be of approximately the same age as the Gurabo formation of the Dominican Republic. Olsson (verbal communication) considers the Bowden formation younger than the Gurabo, and Senn (1940, p. 1582) is of the same opinion.

Knowledge of *Echinochama* is far from complete. There are some subspecies and probably some species of the genus still to be

[1] Published by permission of the Secretary of the Smithsonian Institution.

discovered. Even the Recent species are not well enough known, and more information on the distribution of the Brazilian specimens is needed. Data on the fossil specimens are much less complete, and the classification heretofore has been based on a relatively few specimens from generally well-known localities. More careful collecting of fossil material will enhance the knowledge of the evolution of *Echinochama*.

SYSTEMATIC DESCRIPTIONS

Genus ECHINOCHAMA Fischer, 1887

Genotype.—(Monotypy) *Chama arcinella* Linné, 1767. Recent, Caribbean Sea.

Arcinella Schumacher, 1817, not *Arcinella* Oken, 1815.

Following his description of *Arcinella*, Oken presented a list of abbreviated names, including *arcin.*, under the abbreviated heading *Ch.* Stewart (1930, pp. 149, 150) doubts that Oken intended this list to be included in his genus *Arcinella*. After examining Oken's original work, I agree with Stewart's conclusion. If the other view is taken, however, it would mean that *Chama arcinella* Linné would be the type of *Arcinella* by absolute tautonymy. Stewart (1930, p. 149) designated a type for *Arcinella* of Oken—*Chama calyculata* Linné, which is a carditid.

Description.—*Echinochama*, like some other chamids, loses its attachment in the adult stage and lies on the bottom on one valve, apparently kept in that position by the long spines. The loss of attachment has been combined with some other striking morphologic changes in *Echinochama*. The growth of the shell occurs in three stages which correspond to Jackson's (1890, pp. 293, 294) nepionic, nealogic, and ephebolic periods.

The nepionic shell (text figs. 1, 11, 12) is equivalve, free, and unusually large. It is easily observed on both living and fossil shells, and its maximum size is about 2.3 mm. in length and 1.8 mm. in height. The sculpture of this subrectangular shell consists of from five to seven thin, concentric, widely-spaced ribs. These ribs may show projections on the posterior end of the shell. The beaks are almost at the anterodorsal margin. Two cardinal teeth are present in each valve; they are subequal in the right valve, but in the left valve they are very unequal, the large one bifid. The interior ventral margin is not crenulated.

The nealogic stage begins with an abrupt change in ornamentation, which becomes basically nodular (text fig. 4). Some of the nodules make a netted pattern on the surface of the shell. Some elongate radially and anastomose to form ribs from which spines later arise. Nodules are found between ribs and spines on fully mature specimens and give the interspaces a granulose appearance. Shortly after the first nodular ornamentation is formed, the right valve becomes attached to another shell for a varying length of time. One large specimen, about 34 mm. in height, was observed still attached to *Strombus pugilus*, but attachment at this advanced stage is uncommon. On a few large specimens of *Echinochama* the attachment scar is lost, and it may be possible that some specimens are never attached. The object of attachment is commonly a small, high-spired gastropod, but any kind of shell or shell fragment may be used. Fixation by the right valve is quite consistent, for in more than 1,000 specimens examined, only one was found to be attached by the left valve. The percentage of specimens attached by the left valve may actually be higher, but this is an anomaly which is not easily noticed; however, there appears to be no doubt that attachment by the left valve is very infrequent in *Echinochama*. It is during the nealogic stage that the first spines are formed, the hinge teeth assume the adult appearance, the valves become somewhat unequal in size, and crenulations appear along the interior margins.

The ephebic free stage follows the nealogic attached stage, but the differences in morphology between these two stages are not so well marked as they are between the nepionic and nealogic stages. The shell is porcellaneous. The valves are closed, markedly unequal in one species, slightly so in the remainder. The right valve is slightly higher and in some specimens more convex than the left. The valves of *Echinochama* show a difference in outline when viewed from the interior. The right valve has a

higher umbo and a more angular outline than the left valve. Most of the spines are hollow, for as the shell material grows out, its sides curl ventrally toward each other, forming a tube (text fig. 2). On some large spines the sides do not meet and are only slightly curved toward the ventral side; on others, they curl ventrally to such an extreme that one side overlaps the other. The interior margins of the valves are finely crenulated, and crenulations are seen on some of the hinge teeth. A large round lunule is commonly present below and anterior to the beaks, and the lunular area always contains nodulose ornamentation. The beaks are prosogyrate. On some specimens a shallow sulcus is present which runs from the umbonal region posteroventrally, as it does in many lucinids. This sulcus commonly forms a marked indentation on the posteroventral margin of the shell and on some specimens forms a ridge on the interior of the shell. The ligament is opisthodetic, parivincular, and sunken, but the dorsal side of it can be seen from the exterior. The hinge teeth are greatly modified and variable in the adult shell, probably owing in part to the torsion of the hinge and to secondary splitting of the teeth. In the right valve one large crenulated tooth fits into a deep socket in the left valve. In the left valve a more posteriorly located and less prominent tooth fits into a socket below the ligament. The more complex hinge formulae, based partially on ontogeny, are difficult to interpret in the adult shells of *Echinochama*, and there seems to be little agreement among authorities as to the correct hinge formula. The anterior adductor muscle scar is elongate; the posterior one is larger and more rounded. The pallial line is integripalliate. The most common colors seen on shells of *Echinochama* are purple or reddish-purple. These colors are commonly observed on the nepionic shell and on the interior margins of the adult shell. The *arcinella* rassenkreis ordinarily has reddish-purple coloring, whereas purple is more commonly found in *cornuta*. Yellow is not uncommon on the adductor muscle scars, and on some specimens it is seen occasionally elsewhere on the interior of the shell. Specimens may be colored both yellow and purple.

ECHINOCHAMA ARCINELLA (Linné), 1767

This species is widespread and variable and has at least four named and undoubtedly several unnamed subspecies. The *arcinella* rassenkreis typically shows variation geographically (area) and stratigraphically (time). Heretofore the various subspecies had generally been considered distinct species because of geographic or stratigraphic differences. However, when one compares the morphology of the various so-called species, the extremely close relationship of the members of the rassenkreis becomes obvious, and the subspecies are difficult to separate.

Description.—*Echinochama arcinella* is a relatively large and flat species; the ratio of convexity to height is ordinarily about 0.70. The shell, except for subspecies *olssoni*, is thin, and the umbos are low. The number of rows of spines is greater than in other species of *Echinochama*. On large shells, more than 40 mm. in height, the number of rows of spines is nearly always 20 or greater, some shells having as many as 35.

Geologic age.—Late Miocene to Recent.

Geographic range.—West Indies, Central America, and northern South America.

ECHINOCHAMA ARCINELLA ARCINELLA (Linné), 1767

Plate 119, figure 6

1767 *Chama arcinella* LINNÉ, Syst. Nat., ed. 12, pp. 1139, 1140.

1792 *Chama arcinella* Linné. BRUGUIÈRE, Encycl. Méthod., Vers, vol. 1, pp. 393, 374.

1798 *Chama arcinella* Linné. BRUGIÈRE, Encycl. Méthod., Vers, pl. 197, figs. 4a, b.

1817 *Arcinella spinosa* SCHUMACHER, Essai nouv. syst. habit., etc., pl. 13, figs. 1a, b.

1822 *Chama arcinella* Linné. SOWERBY, Genera of Shells, *Chama*, fig. 2.

1841 *Chama arcinella* Linné. REEVE, Conch. Syst., p. 129, pl. 96, fig. 2.

1846 *Chama arcinella* Linné. CHENU, Illus. Conch., vol. 2, *Chama*, pl. 3, figs. 2, 2a–d, 3, 3a–d.

1846 *Chama arcinella* Linné. REEVE, Conch. Icon., vol. 4, *Chama*, pl. 5, figs. 26a, b.

1853 *Chama arcinella* Linné. D'ORBIGNY in Sagra, Hist. Phys., etc. . . . L'Ile de Cuba, t. 2, Moll., pp. 362, 363, pl. 28, figs. 28, 29.

1853 *Arcinella arcinella* (Linné). MORCH, Cat. Conch. Yoldi, p. 37.

1855 *Chama arcinella* Linné. HANLEY, Ipsa Linn. Conch., p. 91.

1887 *Chama* (*Echinochama*) *arcinella* Linné. FISCHER, Man. Conch., p. 1049.
1889 *Chama arcinella* Linné. CLESSIN in Martini & Chemnitz Conch.-Cab., Bd. 8, Abt. 5, pp. 4, 5, pl. 2, figs. 7, 8.
1938 *Echinochama arcinella* Linné. PILSBRY & MCGINTY, The Nautilus, vol. 51, p. 79.

References to this subspecies were deleted when there was doubt as to the identification of the species referred to under the name *Chama arcinella*.

Description.—This subspecies most closely resembles *E. arcinella californica* but differs from it in having a more rounded outline and in having a slightly greater convexity. The number of specimens examined was 109. The largest one was 53.3 mm. in height. The greatest number of rows of spines seen on a valve was 31, and 29 valves had 20 or more rows of spines. Pilsbry and McGinty (1938, p. 79) give ±16 for the average number of spine rows found on *E. arcinella arcinella*. The average ratio of convexity to height of 12 large specimens was 0.75.

Geologic age.—Pleistocene, Recent.

Geographic range.—The West Indies, except for the Bahamas; the Yucatan Peninsula; Panama; Venezuela; and thence east and south to the island of San Sebastian, Brazil.

ECHINOCHAMA ARCINELLA CALIFORNICA
Dall, 1903
Plate 119, figure 8

1903 *Echinochama californica* DALL, U. S. Nat. Mus., Proc., vol. 26, no. 1342, p. 950, pl. 62, fig. 5 (July, 1903).
1903 *Echinochama californica* DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, pp. 1404, 1406 (October, 1903).
1909 *Chama arcinella* Linné. LAMY, Jour. de Conch., vol. 57, pp. 237, 238.
1932 *Chama* (*Echinochama*) *californica* (Dall). PILSBRY & LOWE, Acad. Nat. Philadelphia, Proc., vol. 84, p. 137.
1946 *Echinochama californica* Dall. HERTLEIN & STRONG, Zoologica, N. Y. Zool. Sci., vol. 31, pt. 3, p. 111.

Description.—This relatively rare subspecies closely resembles *E. arcinella arcinella* (Linné) from the Caribbean region. It differs from the Caribbean subspecies in that the outline of mature shells is angular or subtriangular, particularly the right valve, and the anterior lobe is more distinctly separated from the rest of the shell than it is in *E. arcinella arcinella*.

Twenty-three specimens of *E. arcinella californica* were examined; most of these were young shells. The largest specimen examined was 50.3 mm. in height, and the ratio of convexity to height was 0.67; on a smaller specimen of this same subspecies, it was 0.70. There were 25 rows of spines on the largest specimen, and 26 were seen in two other shells.

Geologic age.—Recent.

Geographic range.—Gulf of California; Cedros Island south to Coiba Island, Panama.

Types.—Lectotype. USNM 96452; two paratypes, USNM 596575.

ECHINOCHAMA ARCINELLA OLSSONI
Nicol, n. subsp.
Plate 118, figure 6

1942 *Chama* (*Echinochama*) *californica* (Dall). OLSSON, Bull. Am. Pal., vol. 27, no. 106, p. 10.

Description.—The shell is much thicker and larger than *E. arcinella californica*. The distinctive character of *E. arcinella olssoni* is the extreme development of large, flat, triangular, unrolled spines, which are noticed

---

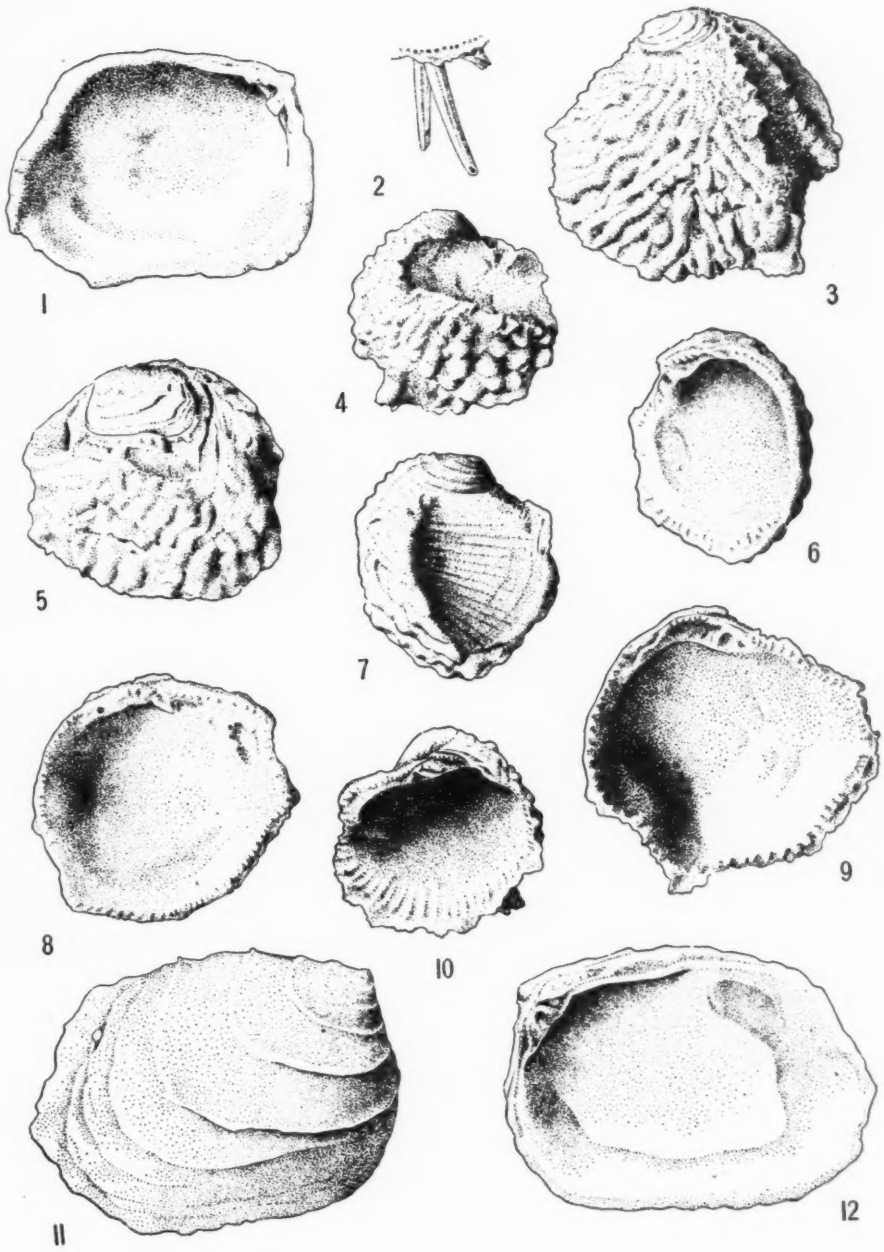
FIGS. *1–12*—Species of *Echinochama*.

1, 11, 12—Echinochama collinsi Nicol, n. sp. Miocene; Mexico. Nepionic shells, *1*, left valve, interior; *11*, right valve, exterior; *12*, right valve, interior, ×15. Paratypes, USNM 561438a (left valve), 561438b (right valve).

2—Echinochama arcinella arcinella (Linné). Recent Samaná Bay, Dominican Republic. A portion of the interior ventral margin showing crenulations and hollow spines with a ventral groove, ×1. Hypotype, USNM 430219.

3, 4, 9, 10—Echinochama collinsi Nicol, n. sp. Miocene; Mexico. Nealogic shells, *3*, left valve, exterior; *4*, right valve, exterior; *9*, left valve, interior; *10*, right valve, interior, ×6. Paratypes, USNM 561443a (left valve), 561443b (right valve).

5–8—Pseudochama draconis (Dall). Miocene, Chipola formation; Tenmile Creek, Calhoun Co., Florida. Nealogic shells, *5*, left valve, exterior; *6*, right valve, interior; *7*, right valve, exterior; *8*, left valve, interior, ×6. Hypotypes, USNM 561444a (left valve), 561444b (right valve).


1
2
3
4
5
6
7
8
9
10
11
12

mainly on or near the ventral margin. Three specimens were lent to me by A. A. Olsson, and the measurements in mm. are as follows:

	Height	Length	Convexity	No. of spine rows
both valves	61.7	62.4	43.2	{28 right 27 left
left valve	67.6	66.7		31
right valve	44.8	46.5		18

The ratio of convexity to height is 0.70.

Geologic age.—Pliocene or Pleistocene, Armuelles formation.

Locality.—Quebrada Rabo de Puerco, near Puerto Armuelles, Chiriqui Province, Burica Peninsula, Panama.

Remarks.—This subspecies is named for Dr. A. A. Olsson, who lent me the specimens for study.

Types.—Holotype, Acad. Nat. Sci. Philadelphia 19193; paratype, Acad. Nat. Sci. Philadelphia 19194; paratype, USNM 561435.

ECHINOCHAMA ARCINELLA ANTIQUATA Dall, 1903
Plate 119, figure 1

1903 *Echinochama antiquata* DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, pp. 1404, 1405, pl. 54, fig. 9.

1925 *Echinochama antiquata* Dall. WOODRING, Carnegie Inst. Washington, pub. no. 366, pp. 106, 107, pl. 13, figs. 1–4; pl. 12, fig. 17 (*Chama involuta*).

Description.—This subspecies is most closely related morphologically to *Echinochama arcinella californica* Dall, but it differs mainly in having more rows of small spines, particularly on the posterior half of the shell. *E. arcinella antiquata* is also somewhat larger than *E. arcinella californica*. Forty specimens were examined, more than half of which were small shells less than 28 mm. in height. The largest specimen measured was 63.5 mm. in height. The largest number of spine rows noted on one valve was 37, and no shell of 40 mm. in height or larger had less than 24 spine rows on one valve. The ratio of convexity to height was found to be 0.69. This subspecies is larger and has a more angular outline and more rows of spines than *E. arcinella arcinella*. The numerous small spines on the posterior half of the shell seem characteristic of *E. arcinella antiquata*.

Geologic age.—Late Miocene, Bowden formation.

Locality.—Bowden, Jamaica.

Types.—Lectotype, USNM 135740; paratype, USNM 561436; hypotype, USNM 352802.

ECHINOCHAMA TRACHYDERMA Pilsbry and Johnson, 1917
Plate 118, figure 1

1917 *Echinochama antiquata* Dall. MAURY, Bull. Am. Pal., vol. 5, no. 29, p. 201, pl. 33, fig. 10 (Feb. 1917).

1917 *Echinochama trachyderma* PILSBRY & JOHNSON, Acad. Nat. Sci. Philadelphia, Proc., vol. 69, p. 197 (April, 1917).

1922 *Echinochama yaquensis trachyderma* Pilsbry & Johnson. PILSBRY, Acad. Nat. Sci. Philadelphia, Proc., vol. 73, p. 416, pl. 46, figs. 1, 2 (Jan. 1922).

1922 *Echinochama antiquata* Dall. OLSSON, Bull. Am. Pal., vol. 9, no. 39, pt. 2, pp. 218, 219, pl. 28, fig. 8 (June 1922).

Description.—This species is variable and widespread. Superficially it most closely resembles *Echinochama yaquensis*, but it has a well developed lunule and is more nearly equivalve than that species. On the other hand, *E. trachyderma*, except for its well developed nodulose ornamentation and few spine rows, closely resembles *E. arcinella antiquata*. The nodulose ornamentation is particularly well developed on the posterior half of the shell of *E. trachyderma*, and on some specimens of this species the ribs bearing the spines are poorly developed.

The largest specimen examined is 62.0 mm. The height is ordinarily 2 or more mm. greater than the length; the ratio of convexity to height is 0.69. The number of rows of spines on specimens of 40 mm. or larger varies from 9 to 16 and averages 12.

Geologic age.—Middle and possibly early Miocene; Cercado and Gurabo formations and probably other formations of the Central American, northern South American, and West Indian areas.

Geographic range.—Costa Rica, Panama, Colombia, Venezuela, and the Dominican Republic.

Types.—Lectotype (specimen Pilsbry called type, 1922, p. 434), Acad. Nat. Sci. Philadelphia 2766. The catalogue number 2786 given by Pilsbry (1922, p. 416) is apparently an error. Three paratypes, Acad. Nat. Sci. Philadelphia 19300.

ECHINOCHAMA YAQUENSIS Maury, 1917
Plate 118, figures 3, 4

1917 *Echinochama antiquata* variety *yaquensis* MAURY, Bull. Am. Pal., vol. 5, no. 29, pp. 201, 202, pl. 33, figs. 11, 12.
1922 *Echinochama yaquensis* Maury. OLSSON, Bull. Am. Pal., vol. 9, no. 39, pt. 2, pp. 219, 220, pl. 28, fig. 5.

Description.—This species is sometimes confused with *Echinochama trachyderma*, but it differs from the latter species by being smaller, having fewer and less developed spine rows, being more inequivalve, and lacking a well defined lunule. *E. yaquensis* is the most primitive species of *Echinochama* from the standpoint of morphology. It is markedly inequivalve; the left valve is flatter and not so high as the right. The lunule is represented by a shallow depression which is not distinctly outlined. The nodulose ornamentation is well defined. The spines are few in number, generally not on well-developed ribs, and the spine rows are few in number and not in well-defined rows. The average ratio of convexity to height is 0.66. The height in mature specimens is commonly 2 to 8 mm. greater than the length. The valve outline is therefore short and high. Maury (1917, p. 201) reported that the average number of spine rows was six, and my examination of specimens indicates that this number is approximately correct.

Geologic age.—Early Miocene? middle Miocene. Apparently rare in the Cercado formation but abundant in the Gurabo formation of the Dominican Republic, also in the lower Gatun formation of Costa Rica.

Geographic range.—Dominican Republic and Costa Rica.

Types.—Two syntypes, Geology Dept., Cornell Univ. 36769.

ECHINOCHAMA COLLINSI Nicol, n. sp.
Plate 118, figure 5; plate 119, figure 2

Description.—This species in the adult is longer than it is high. The umbos are exceedingly high in some specimens and are much higher than in specimens of the *E. arcinella* rassenkreis. The cavity under the umbos is deep. The lunule is deeply depressed. The spines are small but numerous and are arranged in many rows. The average number of spine rows on three specimens of more than 36 mm. in height is 19. The average ratio of convexity to height is 0.81, which is a higher figure than any of the subspecies of the *arcinella* rassenkreis. This species differs from *E. cornuta* in having a more depressed lunule, more spine rows, and a more rounded outline except for the dorsal border.

Geologic age.—Middle Miocene, Agueguexquite formation.

Geographic range.—The type locality is at the head of a small stream which flows into Arroyo Tomas Martinez about 31 km. northeast of Santa Rosa or about 28 km. northwest of San Lucretia near the Vera Cruz-Pacific RR, State of Vera Cruz, Isthmus of Tehuantepec, Mexico; also possibly in the middle or early Miocene of Ecuador.

Remarks.—This species is named for Dr. R. Lee Collins, who was the first to recognize that it was new.

Types.—Holotype. USNM 561437; one large paratype, USNM 350101; five paratypes, USNM 350102, two paratypes (nepionic shells), USNM 561438; two paratypes (nealogic shells), USNM 561443. The remaining paratypes are in the Department of Geology, The Johns Hopkins University.

ECHINOCHAMA CORNUTA (Conrad), 1866
Plate 118, figure 2; plate 119, figure 7

1857 *Chama arcinella* Linné. TUOMEY & HOLMES, Pliocene fossils of South Carolina, pp. 22, 23, pl. 7, figs. 4–6.
1866 *Arcinella cornuta* CONRAD, Am. Jour. Conch., vol. 2, pt. 2, p. 105.
1903 *Echinochama arcinella* (Linné). DALL, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, pp. 1405, 1406.
1916 *Chama arcinella* Linné. MANSFIELD, U. S. Nat. Mus., Proc., vol. 51, no. 2169, pl. 113, figs. 11, 12.
1926 *Pseudochama* (*Echinochama*) *arcinella* (Linné). GARDNER, U. S. Geol. Survey, Prof. Pap. 142-B, pp. 94, 95, pl. 17, figs. 14–16.
1932 *Echinochama arcinella* (Linné). MANSFIELD, State Geol. Surv. Florida, Bull. 8, pp. 92, 93, pl. 18, figs. 1, 4.
1938 *Echinochama arcinella cornuta* (Conrad) PILSBRY & MCGINTY, The Nautilus, vol. 51, no. 3, pp. 78, 79, pl. 7, fig. 7.
1943 *Echinochama arcinella* (Linné). BAYER, The Nautilus, vol. 56, no. 4, pp. 117–119, pl. 13, figs. 13, 14.

Description.—This species includes all the

Miocene, Pliocene, Pleistocene, and Recent specimens of *Echinochama* from the United States. They differ basically from the *arcinella* rassenkreis in the following ways. The ratio of convexity to height is about 0.84, which is considerably higher than in the *arcinella* rassenkreis. The spines are shorter and less cylindrical-shaped, and the spine rows are fewer in number. In the Recent specimens the average is eight spine rows, although a few very large specimens have seventeen or eighteen. The spine rows generally do not increase rapidly in number as the specimen gets larger. The Pliocene and older specimens of this species usually have nine or ten spine rows, although one specimen has as many as nineteen. The Pliocene specimens from the Waccamaw formation of the Carolinas might be considered a distinct subspecies because of their large size and wide-spaced and comparatively few spine rows. The large size is consistent. However, the number of spine rows and other characters vary considerably. In general this northern stock has varied much less than the *arcinella* rassenkreis. Pilsbry and McGinty (1938, p. 79) were the first to point out the differences between the Florida and West Indian specimens.

Geologic age.—Miocene to Recent.

Geographic distribution.—Cape Hatteras to Yucatan, Recent. Fossil, North Carolina, South Carolina, Georgia, Florida.

"This species is erased in our author's revised copy of his work, with the remark "eadem 167" (*Arcinella*)."

There is no indication that Hanley actually saw specimens of *Chama satiata*. Lamy (1928, p. 382) does not place *Chama satiata* in synonymy with *Chama arcinella* but does refer to Hanley's brief note on the species. There seems to be no positive proof from Linné's original description or from his notes made in a personal copy of the *Systema* that *satiata* and *arcinella* are synonymous; and to arbitrarily resurrect the species name *satiata* at this time may cause considerable difficulty in the future.

Cardium? Cochlea? histrix Martyn, 1789. *Cardium? Cochlea? crista-galli* Martyn, 1789. Copies of Martyn's *Universal Conchologist* are so inconsistently printed and contain so many errors that most malacologists have ignored his generic and specific names—a wise course to follow, in my opinion.

Chama bonnani Hanley, 1885. This species was described without reference to an adequate figure and with no definite locality. Although this species may belong to *Echinochama*, it is impossible to identify it with certainty.

Chama lyelli Dall, 1903. This species was described from about ten internal casts found in limestone of supposed late Oligocene age at Jacksonboro, Georgia. Some of the casts clearly show traces of spine-like processes which appear to be similar to those of *Echinochama*. The valves appear to be nearly equal in size. From my examination of the syntypes, I am unable to find out how Dall (p. 1399) was able to claim that this chamid was attached by the left valve.

Echinochama pristina Maury, 1925. This species was described from internal and external casts found in strata of early Miocene age at Rio Pirabas, Brazil. A squeeze of the holotype was examined, but it showed too few morphologic characters for a positive generic identification.

Key to the species of *Echinochama*

1	Nodulose ornamentation predominant	2
	Spinose ornamentation predominant	3
2 (1)	Valves nearly equal, lunule sharply delimited	*E. trachyderma*, pl. 118, fig. 1
	Valves markedly unequal, lunule indistinct	*E. yaquensis*, pl. 118, figs. 3, 4
3 (1)	Average number of spine rows on mature shell about 10	*E. cornuta*, pl. 118, fig. 2, pl. 119, fig. 7
	Average number of spine rows on mature shell about 20	4
4 (3)	Umbos high, umbonal cavity deep	*E. collinsi*, pl. 118, fig. 5, pl. 119, fig. 2
	Umbos low, umbonal cavity shallow	*E. arcinella*, pl. 119, fig. 6

Doubtful species

Chama satiata Linné, 1767. This species was first described in the 12th edition of the *Systema Naturae* and has page priority over *Chama arcinella* Linné, but it was described without reference to locality or figures. No additional information was given in the 13th edition of the *Systema Naturae*. Hanley (1855, p. 88) in his *Shells of Linnaeus* makes the following statement about *Chama satiata:*

Echinochama praearcinella Maury, 1925. This species was described from a fragment of an internal cast of the left valve of a chamid from Rio Pirabas, Brazil. A squeeze of the holotype was examined. The spine-like processes may be those of *Echinochama*, but they appear to be rather elongate and flat. This specimen has some morphologic characters similar to *Chama chipolana* Dall.

ECOLOGY OF *Echinochama*

Some observations on the habits of young *Echinochama* were given in the description of the genus. As soon as the animal reaches a size where the attachment is no longer necessary for stability, it lies on the bottom on one valve and obtains some equilibrium from the radiating spines. There have been no observations on which valve the animal lies during the adult period.

T. L. McGinty (personal communication) placed live specimens of *Echinochama* in his aquarium and observed that they made no attempt to burrow into the sand. J. B. Knight (verbal communication) found live specimens of *Echinochama* in about 9 meters of water off Longboat Key, Florida. He claims that *Echinochama* was found on broken shell, *Lithothamnium*, coral, and gravelly bottoms. McGinty found *Echinochama* most frequently on a bottom of broken shells.

The greatest depth at which *Echinochama* was dredged (data from more than 50 dredging stations) was 81 meters; the shallowest depth reported was about 5 meters. The most common depths from which *Echinochama* was taken ranged from 18 to 45 meters.

There were only seven observations on bottom temperature, and they ranged from 23° to 26° C.

From these data it appears that *Echinochama* lives in warm and shallow water and on shell, gravel, *Lithothamnium*, or coral bottoms.

GEOGRAPHIC DISTRIBUTION OF *Echinochama*

The exact area of origin of the genus is not known, but some evidence points to the Florida region as the possible center of origin of *Echinochama*. This evidence is of two kinds. Among the earliest, if not the earliest, reported occurrences of *Echinochama* is a specimen collected by Mr. Charles Locklin in the Chipola formation of Florida. The earliest previously recorded *Echinochama* in Florida was in the Shoal River formation. The occurrence of *Echinochama* in the Chipola formation should be further verified by more collecting, as it is certainly rare. What appears to be the ancestral species of *Echinochama* is also present in abundance in the Florida region but has not been reported elsewhere. This is not conclusive evidence, and the center of origin of the genus might be in the Caribbean Sea, Central America, or northern South America, including Ecuador or Brazil. Greater refinement of the stratigraphy of the tropical American area and more careful collecting will probably bring us nearer to the solution to this problem. Besides Florida, specimens of *Echinochama* have been found in strata of early or middle Miocene age in the Dominican Republic, Mexico, Costa Rica, Panama, Colombia, and Ecuador.

The late Miocene occurrences do not appreciably extend the geographic range of the genus. Although Gardner (1926, p. 95) states that specimens have been found in the upper Miocene Duplin formation of North Carolina, this report is apparently based on inaccurate data. During the Pliocene the genus did range northward into North Carolina and apparently occupied about the same geographic range it does today. There is no indication that it ever lived north of Cape Hatteras. The southward extension of the genus in Brazil is not definitely known before the Recent.

The present distribution of the genus has been outlined by other workers, but the exact relationship of *Echinochama cornuta* and *E. arcinella* has not been well understood (map, text fig. 13). *E. cornuta* originated in the middle or early Miocene, probably in the Florida area, and has been confined to North America. Today *E. cornuta* extends from Cape Hatteras southward to Florida and thence westward and southward around the Gulf of Mexico to as far south as the Gulf of Campeche. *E. arcinella arcinella* replaces *cornuta* at about the eastern side of the Yucatan Peninsula and extends southward and eastward along the coasts of Central America and northern

FIG. *13*—Distribution of living species and subspecies of *Echinochama*.
Echinochama cornuta (Conrad).....hexagons
Echinochama arcinella arcinella (Linné).....down-pointing triangles
Echinochama arcinella californica Dall.....up-pointing triangles

South America. It is also found on all the islands of the West Indies with the exception of the Bahama Islands. Although the Bahamas have been extensively collected and some lists of mollusks have been published, no mention or specimen of *Echinochama* was noted. *E. arcinella arcinella* extends at least as far as the island of San Sebastian just east of Santos, Brazil. The exact southern limit is not known, and

EXPLANATION OF PLATE 118

All figures ×1.

FIG. *1*—*Echinochama trachyderma* Pilsbry and Johnson. Miocene; Dominican Republic. Right valve, exterior. Lectotype, Acad. Nat. Sci. Philadelphia 2766. (p. 808)

2—*Echinochama cornuta* (Conrad). Recent; Tampa Bay, Florida. Anterior view showing lunule. Hypotype, USNM 445791. (p. 809)

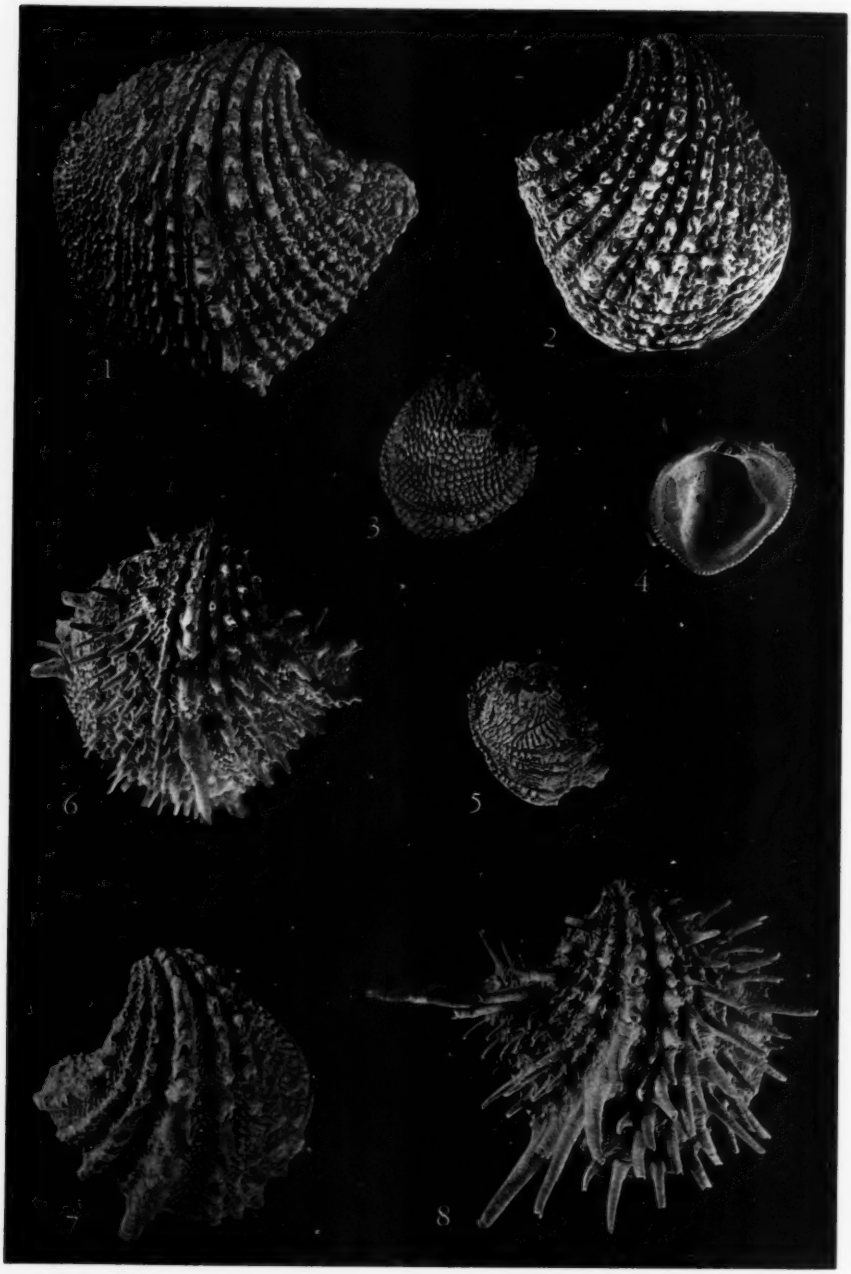
3—*Echinochama yaquensis* Maury. Miocene; Dominican Republic. Right valve, exterior. Syntype, Cornell University, Dept. of Geology 36769. (p. 809)

4—*Echinochama yaquensis* Maury. Miocene; Dominican Republic. Anterior view showing lack of well-marked lunule and small left valve. Hypotype, Acad. Nat. Sci. Philadelphia 19315. (p. 809)

5—*Echinochama collinsi* Nicol, n. sp. Miocene; Mexico. Left valve, interior. Holotype, USNM 561437. (p. 809)

6—*Echinochama arcinella olssoni* Nicol., n. subsp. Pliocene; Panama. Holotype, Acad. Nat. Sci. Philadelphia 19193. (p. 806)

Nicol, Pelecypod genus *Echinochama*



Nicol, Pelecypod genus *Echinochama*

records of the distribution of *Echinochama* in Brazil are meager. The closely related subspecies *E. arcinella californica* is apparently a rare shell occurring in the Pacific Ocean from Cedros Island off Lower California to Coiba Island off Panama. *E. arcinella californica* also extends into the Gulf of California beyond La Paz. Its limits in the Gulf of California are not known. This subspecies has not been reported south of Panama, but this fact is probably due to lack of collecting. Dr. Olsson has permitted me to examine specimens of *Echinochama* from the Miocene of Ecuador. The reason for the poor representation of *Echinochama* in the Panamic Province today is not readily explainable. The *arcinella* rassenkreis has been confined to the southern part of the range of the genus throughout its history. The close relationship of *E. arcinella arcinella* from the Caribbean area and *E. arcinella californica* is obvious when specimens of these subspecies are examined. Apparently these subspecies have been separated from each other for a relatively short time, probably only since the Pliocene.

One anomalous feature of the distribution of *Echinochama* is the relationship of the southern Florida specimens to the northern species, *cornuta*. I have not seen a specimen of *E. arcinella arcinella* from the Florida Keys or mainland. Unfortunately, I have seen only small shells from Cuba, but these appear to be *E. arcinella arcinella*.

When text figure 14 is seen, it is obvious that much additional information is needed on the distribution of fossil *Echinochama*. The distribution maps of the genus are based primarily on specimens seen by me, but a few additional records from the literature were added.

EVOLUTION OF *Echinochama*

The distinctive shell morphology of *Echinochama* appears to make it difficult to find the chamid species that is the ancestor of the genus. There are, however, some basic assumptions which can be made to eliminate the impossible or unlikely species, and by this process of elimination the prob-

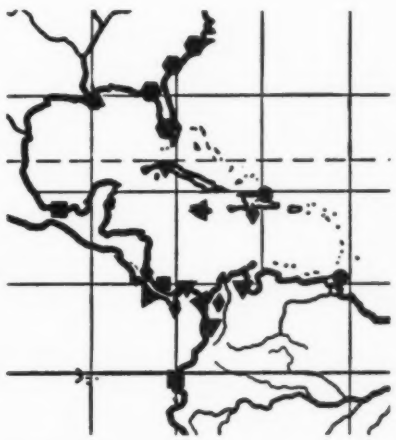


FIG. *14*—Distribution of species and subspecies of *Echinochama* from the Miocene through the Pleistocene Epochs.
Echinochama arcinella arcinella (Linné). Pliocene-Pleistocene—down-pointing triangles
Echinochama arcinella olssoni n. subsp. Pliocene—right-pointing triangles
Echinochama arcinella antiquata Dall. Miocene—left-pointing triangles
Echinochama trachyderma Pilsbry and Johnson, Miocene—diamonds
Echinochama yaquensis Maury. Miocene—circles
Echinochama collinsi n. sp. Miocene—squares
Echinochama cornuta (Conrad). Miocene-Pleistocene—hexagons.

EXPLANATION OF PLATE 119

FIG. *1*—*Echinochama arcinella antiquata* Dall. Miocene; Bowden, Jamaica. Exterior, right valve. Lectotype, USNM 135740. (p. 808)
2—*Echinochama collinsi* Nicol, n. sp. Miocene; Mexico. Left valve, exterior. Holotype, USNM 561437. (p. 809)
3–5—*Pseudochama draconis* (Dall). Miocene, Chipola formation; Tenmile Creek, Calhoun Co., Florida. *3*, right valve, exterior; *4*, left valve, interior; *5*, left valve, exterior. Hypotypes, USNM 349302a (left valve), 349302b (right valve). (p. 815)
6—*Echinochama arcinella arcinella* (Linné). Recent; St. Thomas. Right valve, exterior, Hypotype, USNM 530508. (p. 805)
7—*Echinochama cornuta* (Conrad). Recent; Longboat and Siesta Keys, Florida. Left valve, exterior. Hypotype, USNM 404362. (p. 809)
8—*Echinochama arcinella californica* Dall. Recent; Cedros Island, Lower California. Left valve, exterior. Lectotype, USNM 96452. (p. 806)

able ancestral species can be indicated with a considerable degree of confidence.

We can first assume that the species which gave rise to *Echinochama* lived in the Caribbean area (including the Gulf Coast of the United States, the West Indies, Central America, and northern South America) during late Oligocene or early Miocene times.

The second major assumption that can be made is that the ancestral species was an inverse chamid or *Pseudochama*. Odhner (1919) clearly showed that the chamids attached by the left valve and those attached by the right valve are two distinct stocks, and that a species consistently attaches by either the left or the right valve. This is certainly true in *Echinochama*, wherein more than 1,000 specimens were observed and only one anomalous one was found. Coupled with this trait of attachment by the right valve is the large and distinctly ornamented nepionic shell of *Pseudochama* and *Echinochama* (text fig. 11). This second major assumption immediately eliminates more than half of the chamid species and leaves only six species to consider seriously.

Some morphological characters will have more significance than others in this problem. The nepionic shell, dentition, muscle scars, ligament, and position of the beaks are relatively stable characters in *Pseudochama* and are of little importance at this part of the problem, but they are of importance in eliminating the obviously unrelated species. On the other hand, it must be understood in what ways *Echinochama* is unique, and one must realize that the ancestral species did not, and in some instances could not, have had the morphological characters present in *Echinochama*.

In the description of *Echinochama* I have mentioned three stages of shell development: A, the free nepionic stage, B, the attached nealogic stage, and C, the free, spinose, ephebic stage. The unique part of this development in *Echinochama* is the last, and the ancestral species either never attained it or manifested it only feebly. In other words, the ancestor went through stages A, B, and B′, whereas *Echinochama* goes through stages A, B, and C. With the development of the free-living spinose stage, there was developed an almost equivalve shell. With the decreased size of the attachment scar and the development of an almost equivalve shell, the lunule in front of the beaks could appear. Perhaps the extreme development of the spines was necessary for the shell to have some stability on the bottom because it was no longer attached.

From the previous discussion on morphology, we have limited the possibilities of the ancestral species even more, and we can assume that the ancestor had the following morphologic characters. The ancestor was a *Pseudochama*. It was inequivalve and had a large area of attachment on the right valve, whereas the left valve was comparatively flat or lid-like. Spines were feebly developed or absent, but a nodulose type of ornamentation was well developed. The nodulose type of ornamentation is the only kind found on *Echinochama* after the nepionic stage and before the spines first develop. Nodulose ornamentation is seen on adult specimens of *Echinochama* on the lunule and umbo and between the rows of spines. The interior margins were, in all probability, crenulated as in *Echinochama*.

The six species of *Pseudochama* which appear to be most probably ancestral to *Echinochama* from the standpoints of morphology, geographic distribution, and chronogenesis are *Pseudochama riocamica* (Maury) from the Miocene of Santo Domingo, *P. scheibei* (Anderson) and *P. corticosaformis* (Weisbord) from the Miocene of Colombia, *P. buchivacoana* (Hodson) from the Oligocene of Venezuela, *P. quirosana* (Hodson) from the Miocene of Venezuela, and *P. draconis* (Dall) from the lower Miocene of Florida. Type specimens of all of these species were examined.

Pseudochama scheibei and *P. corticosaformis* appear to be closely related, if not the same species. The lack of well developed nodulose ornamentation and the rounded right valve would eliminate either of these species as the ancestor of *Echinochama*.

Pseudochama riocamica and *P. quirosana* appear to be closely related and are both thin shells without crenulated interior margins. Neither of these species is likely to prove to be the ancestor of *Echinochama*.

Superficially *Pseudochama buchivacoana* appears to be closely related to the hypothetical ancestor of *Echinochama*. The

nodulose ornamentation, however, is diamond-shaped rather than rounded, the umbos are high, the umbonal cavity is deep, and the interior margins do not appear to be crenulated.

Pseudochama draconis (Dall) from the Chipola formation, lower Miocene of Florida, has a nodulose shell with crenulated margins. Dall (1903, p. 1399) made the following remark about *P. draconis:*

"This is a rather common species with a surface recalling that of *Echinochama.*"

From the standpoints of geographical distribution, chronogenesis, and morphology, *Pseudochama draconis* (Pl. 119, figs. 3–5) is the probable ancestor of *Echinochama.* See text figure 15.

The early nealogic stage of *Pseudochama draconis* and *Echinochama* are so much alike that they cannot be distinguished (text figs. 3–10). Differentiation of morphologic characters takes place when the shells reach a size of from 5 to 7 mm., but shells less than 5 mm. are essentially alike in the two groups. If a mature shell of *Echinochama* attains a height of 35 mm., then the mutation or mutations which affected the change produced their first phenotypic manifestation when the shell had attained only about 0.14 to 0.20 of its total growth.

It is becoming more and more evident that the mutation or mutations which occur to derive a new genus or higher category affect the young stages of the shell, and the transition, if such an event occur, from the ancestor to the new genus *Echinochama* was rapid. Serious doubts should be raised concerning the old cliché that no transitional forms are found between most genera and all higher categories because these transitional forms are few in number and the geological record inadequate.

Because of the paucity of information on fossil specimens of the genus and differences of opinion among stratigraphers as to the exact age equivalence of certain strata, our knowledge of the relationship of species and subspecies of *Echinochama* is still very incomplete.

The most primitive species from the standpoint of morphologic characters is *Echinochama yaquensis.* This species apparently occurs along with *Echinochama trachyderma,* a much more modern-looking shell, in the Gurabo Miocene formation of the Dominican Republic. In beds as old or older in Florida, *Echinochama cornuta* is found. It seems that primitive-looking and modern-looking species of *Echinochama* appeared at about the same time, but the primitive forms, those with preponderance of nodulose ornamentation, disappeared at about the end of Miocene time. The main stocks of *Echinochama* appeared by late

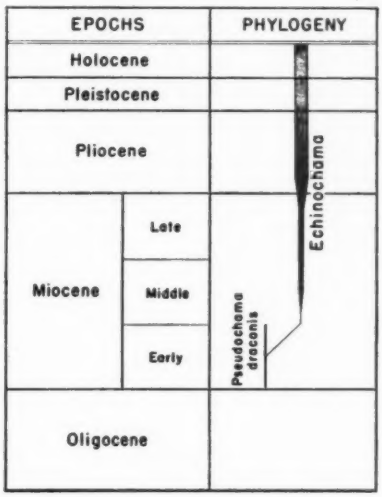


FIG. *15*—The probable origin of *Echinochama.*

Miocene time, and little change has taken place since then. The two main lines of differentiation, the *arcinella* rassenkreis in the southern part of the geographic range of the genus and the species *cornuta* in the northern part of the geographic range of the genus, were established by late Miocene time.

ADDENDUM

Dr. H. S. Lopes of the Instituto Oswaldo Cruz, Rio de Janeiro, Brazil, and Dr. C. N. Gofferjé of the Museu Paranaense, Brazil, have each sent one large specimen of *Echinochama* to the U. S. National Museum since this manuscript was submitted for publication. Both specimens were collected along the coast of the State of Santa Catarina; one of them came from Ilha de Santa Catarina. A more complete account of the southern limit of the distribution of *Echinochama* on the Brazilian Coast will

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 818–828, PLS. 120, 121, 8 TEXT FIGS., SEPTEMBER 1952

REDESCRIPTION OF TWO GASTROPODS NAMED BY CRAGIN

KEITH YOUNG
University of Texas, Austin

ABSTRACT—*Nerinea pellucida* and *Cerithium proctori*, described in 1893 by Cragin, are re-examined, the latter species being transferred to *Ceritella*. New information is given on the ontogeny, generic relations and occurrence of both species.

INTRODUCTION

THIS is the first of a series of papers in which fossils described by Cragin (1893) are revised and redescribed in the light of paleontologic advances of the last half century.

The writer wishes to express his appreciation to Dr. H. B. Stenzel for valuable aid and criticism, to Prof. W. H. Mathews for many suggestions, to the Texas Memorial Museum and the Bureau of Economic Geology for permission to study collections, and to the University of Texas Research Institute for financial support.

SYSTEMATIC DESCRIPTIONS

CERITELLA PROCTORI (Cragin)
Plate 120, figures 1–14

Cerithium proctori CRAGIN, 1893, Geological Survey of Texas 4th Ann. Report, for 1892, p. 222, pl. 42, figs. 11, 12.
Cerithium proctori Cragin; ADKINS, 1928, Univ. Texas Bull. 2838, p. 188.
Pseudonerinea proctori (Cragin); STANTON, 1947, U. S. Geol. Survey, Prof. Paper 211, pp. 95–96, pl. 63, figs. 22–25, 28–30.

Cragin's original description (1893):

Shell of medium size, elevated, consisting of about fourteen (12–16) whorls; spire tapering slowly in the main, but often more rapidly in the upper part, so that the lower part is a frustum of a cone, the upper part a conoid; whorls more than twice as broad as high, nearly flat, slightly convex, crossed by oblique striae, or folds, which, on the body whorl are coarse and pass in a flexuous manner continuously across the side and base of the whorl to the columella, marking stages in the advance of the labial margin. A single example shows faint traces of several revolving lines on the body-whorl, but most of the specimens appear perfectly plain except for the oblique growth-lines.

Measurements.—Height of shell 55, breadth of body-whorl 15 mm., divergence of slopes in lower half of shell 15 (rarely 13) to 20 degrees.

Occurrence.—One of the specimens on which this species is based was found by Mr. Proctor in a mass of Caprina limestone, in drift on the northwest outskirts of Austin. It is preserved in calcite, incrusted with red oxide of iron, like specimens from the Barton creek beds which yield *Pleurocera texana*, *Trochus texanus*, and other beautiful corals and gasteropods, a number of which have been described by the late Dr. Roemer in his last memoir on Texas fossils.

Several less perfect specimens have been collected by Prof. Brown from the Caprina limestone at Deep Eddy bluff, on the right side of the Colorado river between South Austin and the dam.

The example outlined in Figure 12, of Plate XLII, was collected either in Hood or in Gillespie county.

Additional observations.—The shell is high-spired, many-whorled, and elevated; the spire tapers slowly, often more rapidly in the young (seven plus or minus whorls). The shell height of 55 mm. mentioned by Cragin (1893) is greater than any in the topotype collections. The largest individual in the collections studied for this paper is incomplete, but exceeds a height of 45 mm. if restored. Two individuals with entire or nearly entire apertures have shell heights of 29.2 (width 11.8) and 38.3 (width 12.7) mm. Other incomplete individuals range from a 15.3 mm. juvenile to that of the 45.0 mm. maximum. Stanton (1947) mentions an incomplete individual 41.0 mm. in height. The height and width appear to be in direct ratio throughout the later growth stages, but data on complete individuals are insufficient to be conclusive. Two or three individuals appear to retain the protoconch, but the calcite preservation is so rough that the form of the protoconch could not be determined.

Cragin's statement as to the number of whorls seems to be correct. The number of whorls in the larger individuals varies from eleven to fourteen, but the spires are nearly always broken initially.

The whorl width is from two to three times the whorl height, and these two fea-

tures approach a direct ratio (figure 1). Plotting the whorl width against the whorl number (see Burma, 1948, for method of obtaining whorl number) indicates that there was an increase in width with age if the whorl number represents true age, which it does not (figures 2 and 3). Converting these figures to relative age after the method of Burma (1948) shows that increase in width is actually decelerated with age (figure 4), an adult having required a greater increment of time to add a complete whorl than a juvenile individual. Similar results are obtained if whorl height is plotted against whorl number, but the method of obtaining the whorl number influences these figures and the resulting curve.

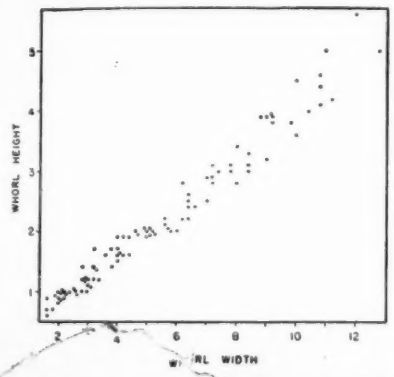


FIG. 1—Ontogenies of ten topotype individuals of *Ceritella proctori* (Cragin). Whorl height plotted against whorl width. Whorl height and whorl width appear to increase at a direct ratio. The apparent increase in variability with increase in age is probably the result of choosing an arbitrary whorl height as a zero whorl. Any variations resulting from rates of growth are not considered at the zero whorl, but are cumulative as measurements are more removed from the zero whorl (fig. 2). Figures are in millimeters.

The suture is impressed and superior and adjacent to a well-defined selenizone. The sutural slope is not consistent in the species or within one individual, and varies from four and one-half to sixteen degrees in different individuals. This inconsistency in sutural slope may be related to "vermetid" tendencies (Delpey, 1941) in some species of Ceritellidae, or it may result from varying food conditions resulting in varying rates of growth. The apical angle varies from 20 to 28°.

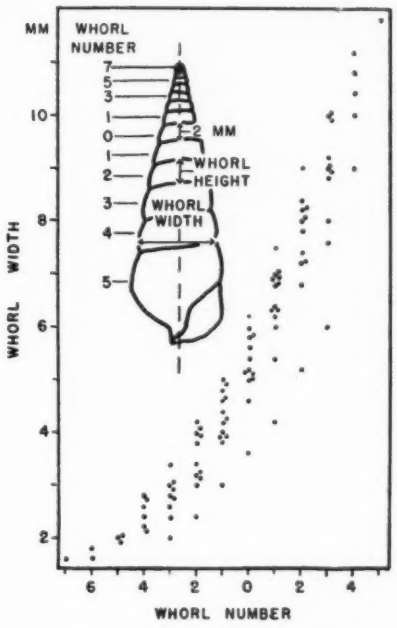


FIG. 2—Methods of mensuration, and ontogenies of 13 topotype individuals of *Ceritella proctori*. The width of the whorl increases as a logarithmic function of the whorl number as indicated by figure 3. Mensuration is modified after Burma (1948). Burma chose a 3 mm. whorl height as the zero whorl. Figures from a larger number of individuals were obtainable with a 2 mm. whorl height as zero whorl in the present study. Burma used the radius vector as a measurement. Because of greater ease of measurement the writer chose to measure the whorl diameter (width) at the position indicated on the figure. Length of body chamber could not be measured because the body chambers are incomplete in 99% of the individuals. As in Burma's (1948) figures 21 and 22, the present curves show practically straight-line relationships on a semilogarithmic plot (figure 3). In addition to its use in obtaining a relative age factor, in most Cretaceous gastropods it is necessary to select an arbitrary whorl number because the apices and apertures are broken or effaced.

The aperture and whorl-section are fusiform in cross section, the aperture being more spindle-shaped because of the anterior canal and the posterior notch. The notch is drawn out into a long slit adjacent to the previous whorl (figure 5 and plate 120, figures 1 and 12). The shoulder is rounded and the base is not sharply delineated from the flank. The columella is perceptibly

drawn out, and is imperforate. Between the basal portion of the columella and the anterior canal is a small pseudoumbilicus, produced by the deflection of the columellar lip from the base. Internally and near the base the columellar lip is provided with a low fold which is produced by the continuous and narrowly restricted deposition of a columellar callosity over the columellar lip. The fold serves as one side of the anterior canal and a reentrant of the outer lip serves as the other side. Although the notch and anterior canal are observable on the last whorl, deposition of wash and thickening of the interior of the shell obscure these features on the interior of the spire and on internal molds.

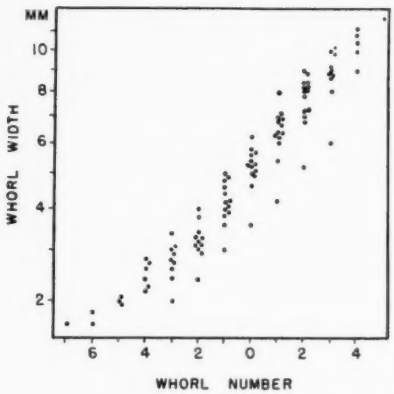


FIG. 3—Ontogenies of the thirteen individuals of figure 2 plotted on semilogarithmic paper.

The ornamentation consists of growth lines and on many individuals, spiral, faintly granulose lirae or threads. The growth lines slope from right to left across the whorls, straighten just basal to the shoulder, and swing back to the anterior canal. The outline of the outer lip is semicircular. High on the whorl the growth lines are reflected to the right and produce a notch at the selenizone. The growth lines are incorrectly drawn in figure 11, plate 42 (Cragin, 1893), reproduced here as figure 6, plate 120; in this figure the posterior notch is not sufficiently accentuated, and the growth

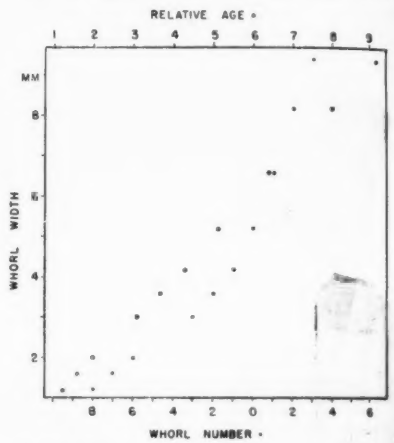
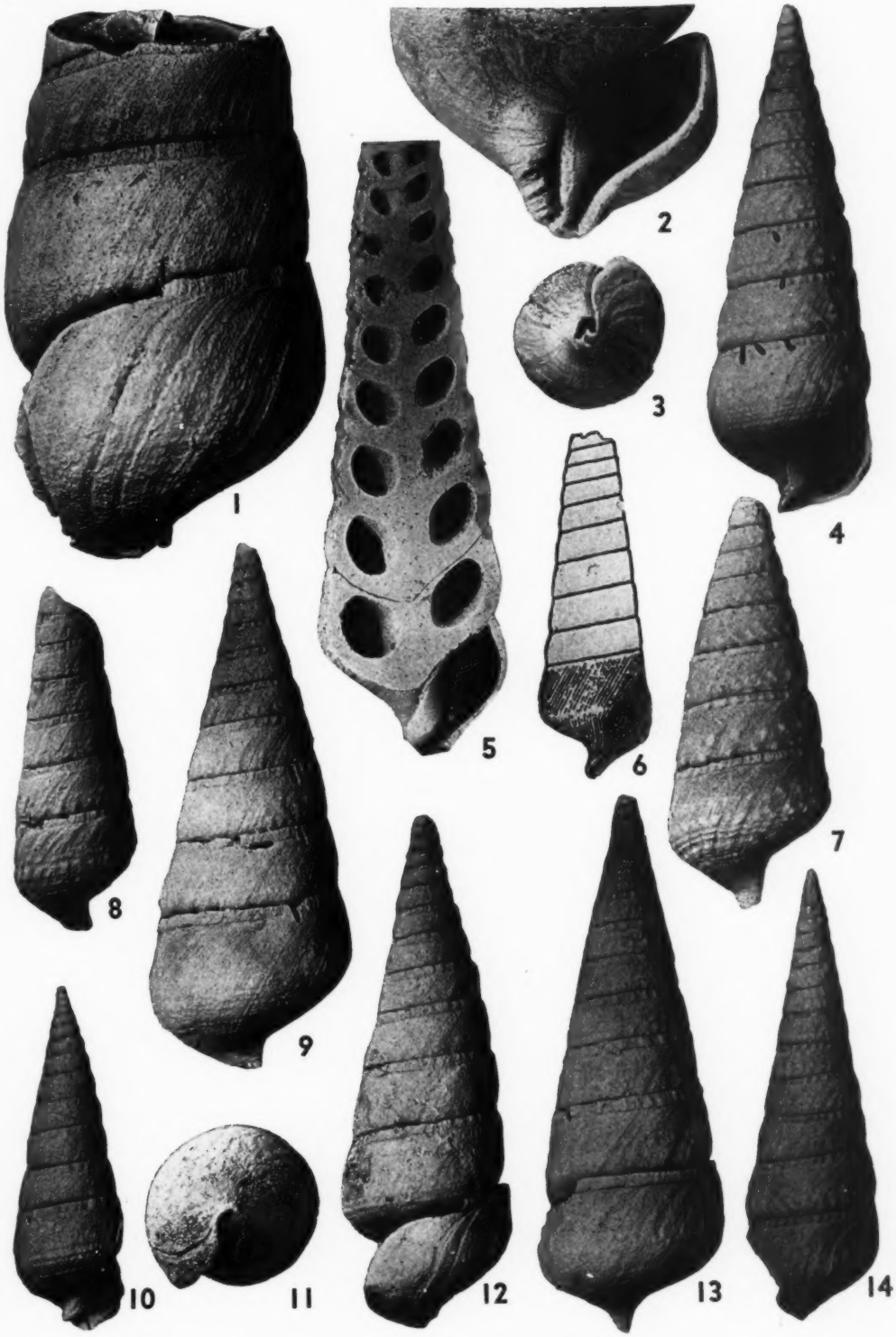


FIG. 4—Ontogeny of a topotype individual of *Ceritella proctori*, illustrating the result of conversion to relative age after the method of Burma (1948). If the conversion to relative age is correctly assumed, then the whorls do not represent time increments; an adult required a longer period of time to add a complete whorl than did a juvenile. In conversion to time values the ontogenetic curve of whorl height plotted against whorl number (figure 1) was used after the method of Burma (1948, figs. 11 and 12, and accompanying text).

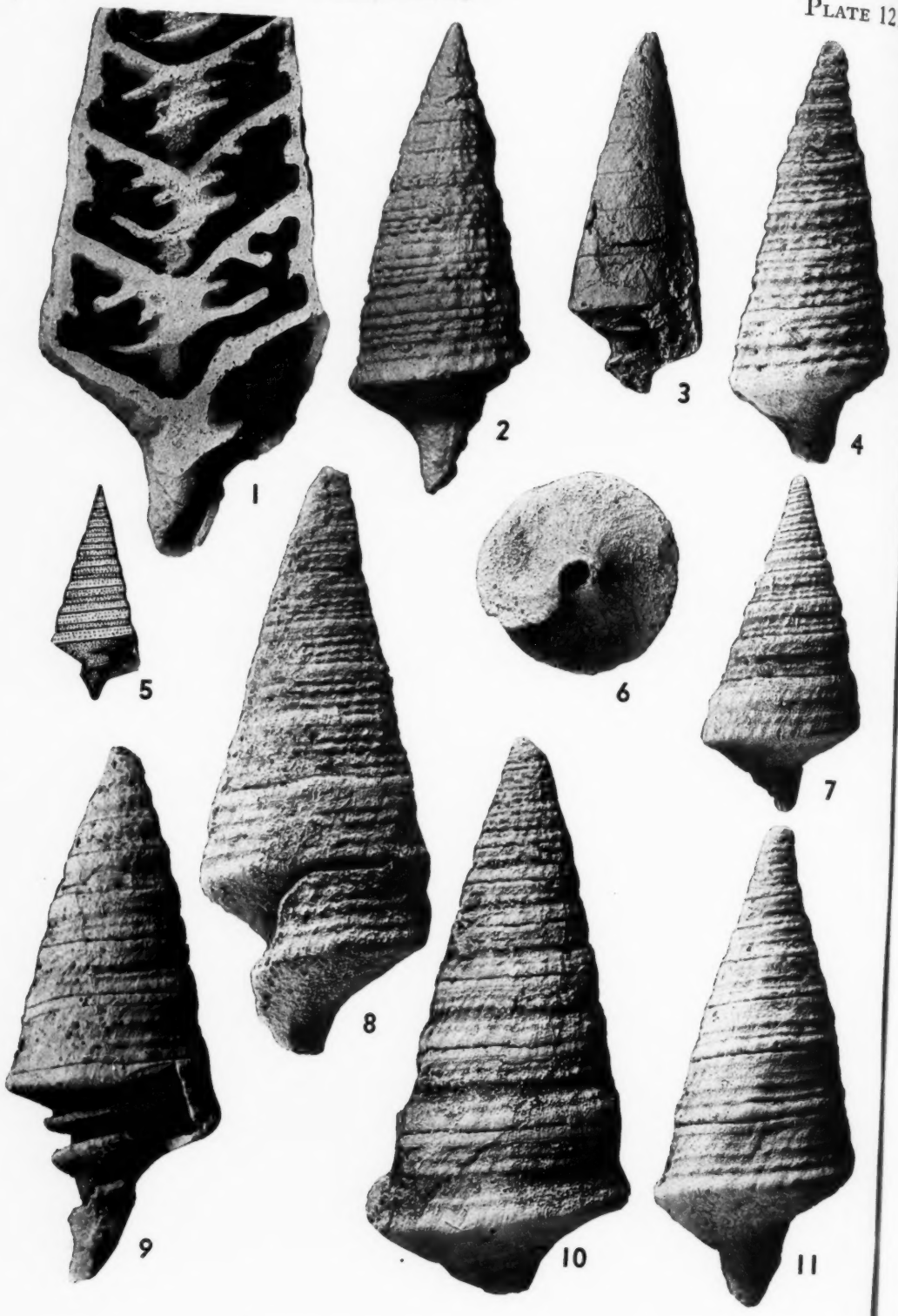
EXPLANATION OF PLATE 120

FIGS. *1–14*—*Ceritella proctori* (Cragin); *1*, Illustrating the slit and selenizone; *2*, the only complete aperture known to the writer; *5*, longitudinal section; *6*, reproduction of Cragin's illustration (1894, pl. 42, fig. 11); *7–11*, basal views; *4*, *7–10*, *12–14*, lateral views illustrating variable morphology and orientation; *1*, *2*, ×4; *6*, Cragin's figure ×1; *3–5*, *7–14*, ×2; *1*, *7*, *9*, numbers 19434, 19435 and 19435 respectively, Bureau of Economic Geology, Austin, Texas; *2*, *3*, *12*, number 19433, Bureau of Economic Geology, Austin, Texas; *8*, *11*, Brown collection, numbers 19437 and 19438 respectively, Bureau of Economic Geology, Austin, Texas; *6*, according to Stanton (1947) USNM no. 32697, Washington, D.C.; *4*, *5*, *10*, *13*, *14*, numbers 1097-4, 1097-5, 1097-10, 1097-13 and 1097-14 respectively, Texas Memorial Museum, Austin, Texas; *1*, *4*, *5*, *7–11*, *13*, *14*, from Deep Eddy bluff locality 50-10, Travis County, Texas; *2*, *3*, *12*, from one-half mile below Tom Miller dam on the right side of the Colorado River, locality 49-61, Travis County, Texas; *6*, Cragin's locality only that this shell is from Travis County, but according to Stanton (1947) it is from the Edwards limestone northwest of Austin, Texas.

(p. 818)



Young, Texas Cretaceous *Ceritella*



Young, Texas Cretaceous *Nerinea*

lines do not curve into the anterior canal. Cragin's (1893) figure 12, plate 42, probably is a correct interpretation, but the lack of perspective at the base gives a false impression, and the slope of the growth lines is insufficient.

The selenizone forms the superior portion of the whorl (is subsutural) and is marked by a longitudinal ridge, faintly granulose, which is delineated from the rest of the whorl by a faintly impressed spiral line. In some individuals there is evidence of further spiral ornamentation (see Stanton, pl. 63, figures 22 and 23, and this paper, plate 120, figures 7 and 8), although others, equally as well preserved, show little or no spiral ornamentation. There may be as many as three spiral rows of faint granules on the shoulder, one or two of which are overlapped by later whorls. They do not appear on the internal molds. The eight or ten faint spiral threads mentioned by Stanton (1947) and Cragin (1893) can be observed on many individuals in the collections; but the number of these spiral threads may be considerably less than eight or ten. None of the individuals shows the perfect ornamentation of some of those from the Hill Collection (Stanton, 1947, plate 63, figures 22 and 23), and others from the Brown collection (this paper, plate 120, figure 1) are nearly as inornate as the individuals of *Pseudonerinea ? presidiensis* Stanton (1947, Plate 63, figs. 26 and 27). Many of the individuals from the Brown collection lack the granulosity of the selenizone, the selenizone being ornamented only with short growth lines as in *P. ? presidiensis*.

Remarks.—Ceritella proctori (Cragin), *Pseudonerinea ? presidiensis* Stanton, and *P. ? terebroides* Stanton appear to be congeneric as pointed out by Stanton (1947), but *P. terebroides*, and particularly its subspecies *P. terebroides glabra* Stanton, is distinct because of its usually pronounced ramp. The apical angles of both *P. terebroides* and *P. presidiensis* are less than that of *C. proctori*, and the size of *P. presidiensis* as described by Stanton is much greater than that of *C. proctori*. Although the three species appear to be congeneric definite generic assignment of *P. presidiensis* and *P. terebroides* awaits apertural descriptions.

The disposition of the growth lines is sufficient to distinguish individuals of *C. proctori* and its variants from most fossils that occur with them. During mensuration of a number of individuals of *C. proctori* an undescribed gastropod from the Edwards limestone was inadvertently measured with them. This new species has the same shape as *C. proctori*, with corresponding height, width, and whorl height values. Although the growth lines are disposed differently and there is no visible selenizone in the new species, the internal molds of the two species would most likely be identical.

Generic affinities.—The genus *Ceritella* Morris and Lycett (1850) has been subdivided into *Ceritella* s.s., *Fibulella* Wenz (1940), and *Sequania* Cossmann (1895). *Pseudonerinea* Loriol and Koby (1890) may

---

EXPLANATION OF PLATE 121

FIGS. *1–11*—*Nerinea pellucida* Cragin: *1*, longitudinal section illustrating the internal folds; *3*, badly eroded individual in the type collection of the Bureau of Economic Geology, Austin, Texas; this individual is the only remaining specimen that can be considered a syntype and automatically becomes the holotype; *5*, Cragin's illustration (1893, pl. 42, fig. 5) reproduced; *6*, basal view (see also this plate, fig. 8); *8*, lateral view showing notch and slit (see also this plate, figure 6); *2*, *4*, *7*, *9–11*, lateral views illustrating variation of morphology and ornamentation; *1*, number 1098-1, Carl Chelf collection, Texas Memorial Museum, Austin, Texas; *2*, *7*, *9*, *10*, numbers 19442, 19446, 19447, and 19448 respectively, Bureau of Economic Geology, Austin, Texas; *3*, number 19443, Bureau of Economic Geology, Austin, Texas; *4*, *11*, numbers 19444 and 19449 respectively, Brown collection, Bureau of Economic Geology, Austin, Texas; *5*, the individual figured by Cragin (1893) was never designated and its whereabouts is unknown; *6*, *8*, number 19445, Bureau of Economic Geology, Austin, Texas; *1*, locality 50-11, Barton Creek, Travis County, Texas; *2*, *4*, *6–11*, locality 50-10, Deep Eddy bluff, Travis County, Texas; *3*, Deep Eddy bluff, locality 50-10, Travis County, Texas; All figures ×4 except figures *3* and *5*; *3*, ×2; *5*, Cragin's figure 5, plate 42, ×1.

(p. 823)

be a closely related genus, although Wenz (1940) questions its ceritellid affinities and Cossmann (1895–96b) considered this genus synonymous with *Fibula* Piette (1857), but may later have changed his opinion. The writer has not had the opportunity to study European representatives of the family, but Cossmann (1895–96b) and Wenz (1940) definitely indicate that *Pseudonerinea* is broadly sinusate at the base, whereas *Ceritella* possesses a short, narrow anterior canal.

Ceritella proctori (Cragin) is not readily classified in any of the described subgenera and may represent a new subgenus. The body whorl of *Ceritella* s.s. is much larger in relation to the spire than in *Ceritella*

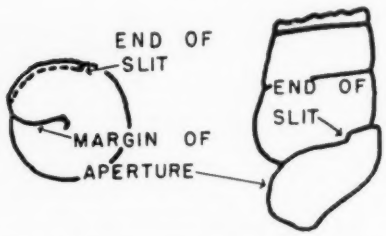


FIG. 5—Diagrammatic illustration of angle of slit in *Ceritella proctori*.

proctori, and the base is more vaulted, the anterior canal being less perfectly formed. *Fibulella* Wenz [type: *Fibula undulosa* (Piette) by original designation] lacks a true canal if Piette's (1857) figures 6 and 8, plate 6, are correct. Piette's (1857) figure 4 plate 6, shows faint, imperfect channeling, but this figure is not of the type species. Also, Piette's figures illustrate a holostomal aperture at the posterior notch, showing no slit, but Piette may have erred in interpreting the aperture from incomplete individuals. A lectotype for *Fibulella undulosa* has not been designated, but Piette's (1857) figure 6, plate 6, has always been reproduced by subsequent authors who illustrated the species. Apparently this figure was redrawn for the illustration in Zittel (1913) figure 978, page 550, and was misinterpreted in the redrafting. Since there has been no hesitation by authors to place *Fibulella* Wenz in the Ceritellidae and the Nerineacea, Piette's figures may be in error. Certainly many "*Fibula*" described by Cossmann as belonging to Piette's genus (*Fibulella* Wenz replaces *Fibula* Piette 1857 non Leske 1778) are unlike Piette's figures of the type species.

Ceritella proctori most nearly approaches the subgenus *Sequania* Cossmann (1895), but has more refined ornamentation, tending toward granulosity rather than transverse ribbing, and a greater slope to the growth lines. The anterior canal is almost identical with that in illustrations of *Sequania lorioli* Cossmann, the type species of *Sequania*, but *Ceritella proctori* may possess more of a columellar fold at the interior margin of the anterior canal. Further studies of the ceritellid gastropods of the Albian of Texas may reveal that these species merit a new subgenus.

Habitat and associated species.—*Ceritella proctori* (Cragin) at the type localities occupies a biostromal facies in the Edwards limestone. It is associated with other Cretaceous fossils occupying biostromal environments. Fossils occurring with topotypes of *C. proctori* are:

Gastropoda: "*Architectonica*" *planorbis* (Roemer), "*Trochus*" *texanus* Roemer, *Nerinea* s. l. *pellucida* Cragin, *Nerinea pseudoconvexa* Stanton, *Pleurotomaria increbescens* Stanton, *Margarites brownii* (Cragin), *Margarites bartonensis* Stanton, *Monodonta minuta* Stanton, *Monodonta bartonensis* Stanton, "*Solariella*" *serrata* Stanton, *Rimula vaughani* Stanton, *Pileolus whitneyi* Ikins and Clabaugh (=*Pileolus septangularis* Stanton), *Triforis* ? *antiquus* Stanton, *Teinostoma* ? *austinense* Stanton, *Trochactaeon parvus* Stanton, *Epitonium* ? *austinense* Stanton, "*Cerithium*" *bartonense* Stanton, "*C.*" *kickapooense* Stanton, "*C.*" *shattucki* Stanton, "*C.*" *obliterogranosum* Roemer, "*C.*" *coloradoense* Stanton, "*C.*" *austinensis* Roemer, "*C.*" *roemeri* Ikins and Clabaugh and *Aporrhais brittsi* Stanton.

Pelecypoda: "*Lucina*" *acutelineata* Roemer, *Toucasia patagiata* (White), *Toucasia* sp., *Monopleura marcida* White, *M. pinguisula* White, *Monopleura* sp., *Caprotina* ? *crassifibra* Roemer, and other Pelecypoda.

Hexacoralla: *Cladophyllia furcifera* Roemer and other Hexacoralla.

Localities and Types.—The syntypes (with the exception of one collected in float) were from Deep Eddy bluff on the south side of the Colorado River between South Austin and Tom Miller dam, Travis County.

Texas. According to Cragin (1893) the Brown collection is from this locality. In addition Cragin (1893, pl. 42, fig. 12) figured an individual of which the locality was indefinite. Between the mouth of Barton Creek and Tom Miller dam there are two collecting localities today. One is at Deep Eddy bluff (locality 50-10) on the Colorado River in the Rollingwood section of Austin, Travis County, Texas. A second locality (locality 49-61) is high in the bluff about one-half mile below Tom Miller dam on the southwest side of the Colorado River. Both localities are within the original designation of locality, and individuals from these localities constitute topotypes.

Unfortunately Cragin did not designate types. According to Stanton (1947) his figures 28 and 29, plate 63 are of the individual (U. S. Nat. Mus. #32697) figured by Cragin (1893, pl. 42, fig. 11). The individual represented by Cragin's fig. 12, plate 42, was from an uncertain locality and seems to be lost. In the absence of other designated syntypes the individual figured by Cragin in figure 11, plate 42 (U. S. Nat. Mus. #32697) automatically becomes the holotype of the species. Cragin states that he studied many individuals from the Brown collection. The Brown collection, at least in part, has been utilized in the present discussion, but there is no indication as to what individuals Cragin studied. The Brown collection (from locality 50-10) and the writer's collection (from localities 50-10 and 49-61) of topotype material (numbers 19433 to 19441) are deposited at the Bureau of Economic Geology, Austin, Texas. A collection made by Carl Chelf and now on deposit at the Texas Memorial Museum, Austin, Texas, was also made available to the writer. This collection is from Deep Eddy bluff (accession number 1097, locality 50-10) and contains topotype material. In all several hundred individuals have been collected, but few are complete.

NERINEA PELLUCIDA Cragin
Plate 121, figures 1–11

Nerinea pellucida CRAGIN, 1893, Geological Survey of Texas 4th Ann. Report, for 1892, p. 226, pl. 42, fig. 5.

Nerinea pellucida Cragin; DIETRICH, 1925, in Fossilium Catalogus, I: Animalia, part 31, p. 120. W. Junk, Berlin.

Nerinea pellucida Cragin; ADKINS, 1928, Univ. Texas Bull. 2838, p. 186.

Nerinea pellucida Cragin; STANTON, 1947, U. S. Geol. Survey Prof. Paper 211, pp. 86–87, pl. 62, figs. 9, 10, 12–16.

Cragin's original description:

Shell rather small, spire conical, rather short and broad for the genus, consisting of about twelve whorls, the spire-slopes straight or slightly convex; whorls low, their sides sometimes nearly flat, sometimes constricted on the middle, and prominent at or on either side of the feebly impressed suture; body-whorl and outer lip angulated; aperture between quadrate and triangular, columella prominently produced, pointed, and channeled below, bearing two prominent and sharp lamellar folds, of which the upper and smaller one is situated where the upper wall of the body-whorl springs from the columella, and the lower one about midway between the smaller one and the lower limb of the outer lip, a low and obtuse ridge appearing also within the aperture upon the inner surface of the outer wall of the body-whorl; surface of each whorl ornamented with two broad, low, revolving bands, either of which bears two lines of faint granules, the bands being separated by a shallow constriction, in the bottom of which a quite narrow (? granulated) line, bounded by two striae, is sometimes distinguishable. Among the specimens at hand, those with the sides of the whorls flat present lines of granules, while others are ornamented only with plain raised bands and constrictions, the latter aspect being possibly due to weathering.

Measurements.—Height 33, breadth of body-whorl 11.2 mm.; divergence 14 to 26 degrees. An exceptionally broad example gives height 35, breadth 16.7 mm.

Occurrence.—Caprina limestone at Deep Eddy bluff, on the Colorado river, between South Austin and the dam.

About two dozen specimens, obtained at Deep Eddy bluff by Prof. Brown, are before me. Mr. Proctor has also obtained the species from a drift-fragment of Caprina rock on the northwestern outskirts of Austin.

Additional observations.—This species is rather small, thin-shelled, and delicately sculptured for a *Nerinea*. The size (shell height of 33.0 mm.) of the individual measured by Cragin (1893) is rather large for the species. Stanton (1947) mentions one individual of 35 mm. height and another that would have a height of over 48 mm. if restored, although in the collection of over 200 individuals which he studied all but three are smaller than 24 mm. if restored. If the individuals studied by Stanton are in the same condition as those in the collections studied for this paper, then few are complete. The largest specimen in the col-

lections studied by the writer is 36.0 mm. high and 11.9 mm. wide; the apertural portion is broken off for some unknown distance, and the individual is not a topotype. Only data from topotype individuals are given in figures 1 and 2. The largest topotype measured is 24.5 mm. high and 10.0 mm. wide; it is likewise incomplete at the apertural end. Four topotypes are preserved in their entire height. These heights are 19.3 (width 8.1; this individual has a complete aperture and outer lip and is illustrated on pl. 121, figs. 6 and 8), 7.4 (width 4.2; obviously juvenile), 20.8 (width 8.8), and 15.0 mm. (width 6.0). A few individuals appear to retain the protoconch, but the calcite preservation is so rough that the form of the protoconch could not be determined. No figures can be given for average size because only the four individuals out of several hundred are completely preserved. On the other hand the most fragile portions of the shell are the first few whorls of the spire and the body whorl, and it is usually these that appear to be damaged or destroyed. The growth curves (figures 6 and 7) do not indicate any changes that can be correlated with maturity, except that there seems to be a definite increase in the variability of the whorl width-whorl height ratio at a whorl width of 5 to 6 mm. and a whorl height of approximately 2 mm.

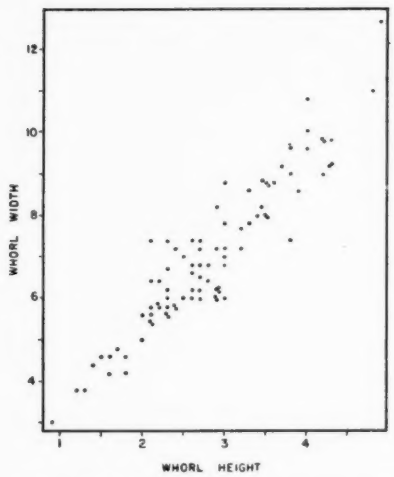


FIG. 6—Whorl heights and whorl widths of the last measurable whorl of 87 topotype individuals of *Nerinea pellucida*. Figures are in millimeters.

Cragin (1893) described the species as consisting of about twelve whorls. On the individuals measured by the writer there are from five to eleven whorls. Only one of the individuals has twelve whorls, but it is incomplete. One entire individual has an over-all height of 15.0 mm. and nine whorls, the spire being entire. On most individuals it appears that from two to six whorls have been broken off or effaced in some other manner.

The slope of the spire is usually straight, but frequently convex, and rarely concave, the extremes of the apical angle being 22° and 37½°. The writer found no topotypes with apical angles of less than 22° and certainly none as low as the 15° figure given by Stanton (1947) as a minimum. In some of the better preserved individuals there is a definite break in the apical angle at about the seventh whorl, but in most individuals such marked dimorphism could not be observed, and in some is obviously not present. One individual decreases 12° in the apical angle between the first seven whorls and the last three whorls. This feature is extremely variable and in only a few individuals is the convexity of the slope easily visible. The dimorphism decreases the accuracy of measurement, but the amount of error is difficult to judge. The spire is almost symmetrical, the sutural slope being very low, varying from four to thirteen degrees.

The whorl width plotted against the whorl height gives a fairly straight curve (figures 6 and 7), and, within limits, the ratio of whorl height to whorl width remains approximately constant whether the largest whorls of different individuals are plotted (fig. 6) or complete ontogenies are plotted (fig. 7). Since this ratio is in some measure proportional to the volume of the body of the animal, it probably represents a linear growth factor.

The whorls may be almost flat-sided (plane), but are usually concave (excavated) and symmetrically excavated in respect to the inferior and superior sutures. Usually the suture is not impressed, being flush with the crest of the fused longitudinal (spiral) lirae bordering it above and below. In a few individuals these two spiral lirae are

separated by a faint impression which is the suture. The body whorl is angulated, but not keeled, sometimes faintly granulose in a low, longitudinal thread just above the angulation. The base is distinct and unornamented except by very faint growth lines or in a few individuals by faint spiral threads (pl. 121, fig. 10). The angulation of the body whorl continues to the outer lip. The growth lines cannot be observed on the base of the inner whorls because of secondary secretion of parietal wash.

The aperture is rhomboid in section rather than quadrate, with the lesser angles at the posterior notch and the anterior canal. The short axis of the rhomboid averages about two-thirds of the length of the long axis. In the one individual in which the outer lip is entirely preserved, the outer lip is notched, the notch being V-shaped and subsutural,

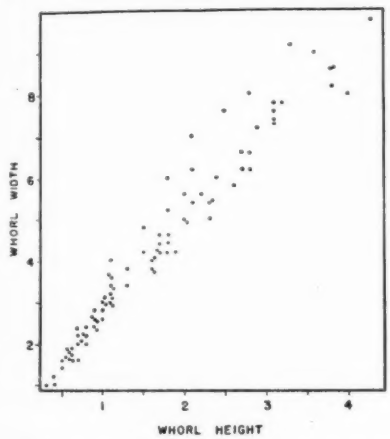


FIG. 7—Ontogenies of ten topotype individuals of *Nerinea pellucida*. Whorl height and whorl width seem to increase at a direct proportion. Figures are in millimeters.

and there is a narrow slit extending from the V-shaped notch (pl. 121, fig. 8). This slit is 2.3 mm. long and about 0.2 mm. wide. The selenizone, which is subsutural (fig. 8), has not been mentioned in the literature previously, presumably because its position is masked by a strong subsutural longitudinal lira which is granulose in some individuals; this lira is not as strong on the last one-half of the body whorl.

The columella and the outer lip are extended at their juncture and form a true canal which is roughly 2 mm. long in entire individuals of average size. There are no denticles or folds on the outer (palatal), parietal, or columellar margins, the columellar, outer, and parietal folds appearing farther back and growing aperturad as the shell grows; they are deep in the body chamber and barely visible in individuals in which the aperture is complete. Cragin's (1893) description of the folds is incomplete,

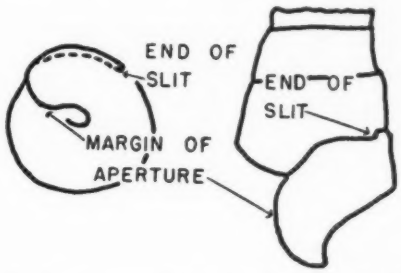


FIG. 8—Diagrammatic illustration of angle of slit of *Nerinea pellucida*. Figures approximately times 4.

but Stanton (1947) rectifies this discrepancy in part. There is a parietal fold (pl. 121, fig. 1) almost at the junction of the parietal wall with the columella. This fold migrates laterad with age, being columellar in juvenile individuals and parietal in more adult individuals. A second fold is columellar, approximately half-way between the parietal fold and the anterior canal. In more mature individuals there is a low columellar stria appearing between the columellar fold and the parietal fold. All of the parieto-columellar folds are internal and do not extend to the lip of the aperture. The low, intermediate stria is ontogenetically later than the parietal and columellar folds; it is not present in juvenile individuals. In four individuals the intermediate stria was observed to be just beginning at shell heights of 16.6, 16.0, 15.2, and 16.8 mm. It was not observed to occur in individuals of less than 13.0 mm., but is present in one individual with a shell height of 13.2 mm. One individual of 17.8 mm. height has no intermediate stria, but all individuals with shell heights greater than 18.0 mm., in which the folds could be studied, possess an intermediate stria, a columellar fold, and a parietal fold. The beginnings of the columellar and parietal

folds could not be studied because of recrystallization by calcite in the replacement of the early whorls.

There is also an internal fold on the outer (palatal) lip; this fold does not reach the edge of the lip. It is not as large as the columellar or parietal folds, but is larger than the intermediate columellar stria. The outer fold is single in juvenile specimens and first appears at a shell height of between 11.0 and 12.0 mm. In more adult individuals the outer fold becomes double. The superior swelling of this fold is directly opposite the parietal fold; the inferior swelling is opposite the intermediate stria.

In more adult specimens there is a small, broad, internal stria on the parietal wall, intermediate between the parietal fold and the junction of the parietal wall with the outer lip (pl. 121, fig.1). This species most closely approaches (but does not correspond to) Delpey's (1941) Grade 7.

The ornamentation consists primarily of four or five (rarely three, except on the juvenile whorls) longitudinal lirae. The sub- and suprasutural lirae are the most prominent, and in some individuals are so closely united as to conceal the suture and form a single spiral ridge. The subsutural lira is as strong or stronger than the suprasutural lira and masks the selenizone. Between the sub- and suprasutural lirae there are two or three smaller spiral threads which may or may not be granulose. In those individuals with more excavated whorls the median longitudinal lira is stronger and more granulose, whereas in indviduals with flattened whorls the lirae are less granulose; there are many annectants. Rarely are the sub- and suprasutural lirae granulose. In some of the more granulose individuals the granulae are secondarily aligned approximately parallel to the growth lines, forming a less typical "cerithial" pattern. In the adult whorls the longitudinal lirae are more continuous and granulosity is weaker. The ornamentation is not as strong on the last half of the body whorl.

In most individuals the growth lines are inconspicuous. Across the flank (this species is not ramped) the growth lines extend from right to left and are reflected to form a notch at the selenizone. On the spire and the first half of the body whorl the position of the selenizone is concealed by the deposition of the subsutural lira, and the slit condition of the shell is not apparent. There is a slight curve in the growth lines on the angulation, and they recurve toward the columella at the anterior canal. A shallow sinus of variable position is present near the shoulder.

Remarks.—This species, although markedly spired, is squat when compared to most *Nerinea*. The only described Texas nerineid approaching this species in gross shape is *Nerinea* (*Ptygmatis*) *ponsaltensis* Stanton. The latter species is much larger, is inornate, and has a large median columellar fold. The outer fold is disposed closer to the base in *N. ponsaltensis* than in *N. pellucida*, and *N. ponsaltensis* lacks the distinctive ornamentaion of *N. pellucida*.

Generic affinities.—All of the genera to which *Nerinea pellucida* Cragin is related are generally considered to be subgenera of *Nerinea* Deshayes (Wenz, 1940; Cossmann, 1898). It seems to the writer that *Nerinea*, as interpreted by Wenz (1940), can be subdivided into two main groups, (1) those with three folds or less, and (2) those with four folds or more. Certainly *Nerinea* s.s., *Fibuloptyxis* Cossmann, *Diozoptyxis* Cossmann, *Acrostylus* Cossmann, and *Melanioptyxis* Cossmann form a distinct and separate group from *Ptygmatis* Sharpe, *Laevinerinea* Dietrich, *Teleoptyxis* Olsson, *Neoptyxis* Pcelinzev, and *Plesioptygmatis* Böse. With such a subdivision *Nerinea* (subgenera *Nerinea* s.s., *Fibuloptyxis*, *Diozoptyxis*, *Acrostylus*, and *Melanioptyxis*) could be differentiated from *Ptygmatis* s.l. (subgenera *Ptygmatis* s.s., *Laevinerinea*, *Teleoptyxis*, *Neoptyxis*, and *Plesioptygmatis*) on internal structure. Two genera now included as subgenera of *Nerinea*, *Gonzagia* Maury and *Aphanoptyxis* Cossmann, do not fit in the above interpretation of *Nerinea* or *Ptygmatis*.

Unlike Wenz (1940) and Cossmann (1898) Olsson (1934) has interpreted *Ptygmatis* s.s. as a Jurassic and Valanginian genus with widely open umbilicus. This interpretation would exclude *Nerinea pellucida* Cragin, *N.* (*Ptygmatis*) *ponsaltensis* Stanton, and other closely related undescribed Cretaceous Nerineidae. As pointed out by Delpey (1941) the present classification is polyphyletic. Further study is required before the true

generic status of these Nerineidae can be satisfactorily established.

If *Ptygmatis* were given generic rank equal to that of *Nerinea* then *Nerinea pellucida* would belong to *Ptygmatis* s.l. This species does not obtain the size attributed to *Ptygmatis*, has a closed umbilicus, and is more conical and less cylindrical. Actually individuals of *N. pellucida* look most like the juveniles of an undescribed species of *Ptygmatis* s.l. from the Middle Albian of Texas. However, it seems incredible that several hundred topotype individuals would all be juveniles at a locality and horizon where there occur no individuals which could possibly serve as adults. The writer is not familiar with the young of *Teleoptyxis* Olsson or with *Neoptyxis* Pcelinzev, but these two subgenera appear to be very close to *Ptygmatis* s.s.

Habitat.—*Nerinea pellucida* Cragin occurs in near-reef (usually biostromal) facies in association with "*Cerithium*" spp., *Ceritella proctori* (Cragin), *Nerinea pseudoconvexa* Stanton, Caprotinidae, *Toucasia* (two or more species), *Monopleura* (three or more species), and many Hexacoralla and Mollusca. The species occupying this habitat are listed more completely on page 822. Most of the individuals collected by the writer appear to have been deposited in the small interbiostromal areas with fragmental and comminuted shell debris of corals and molluscs. This deposition probably accounts for the general breakage of the body whorl and perhaps for the damaged spires. Some of the spires seem to have been eroded slowly. The high-spired shells usually lie parallel to the bedding, but are oriented at random within the plane of bedding.

Localities and types.—The syntypes of *Nerinea pellucida* Cragin are listed from Deep Eddy bluff on the Colorado River, between South Austin and the old dam (Cragin, 1893). This dam has been destroyed by flood, but the present Tom Miller dam is in approximately the position of the former. There are two localities at which these fossils may be collected along the south side of the Colorado River within the original designation of type locality. These localities have been discussed earlier in this paper. The syntypes were probably collected at Deep Eddy bluff (locality 50-10), the locality from which the U. S. N. M. plesiotypes described by Stanton (1947) were collected. A badly eroded specimen on deposit at the Bureau of Economic Geology, number 19443, appears to be an original syntype, and in the absence of other syntypes automatically becomes the holotype (pl. 121, fig. 3).

Some of the topotypes discussed in this paper are from Deep Eddy bluff (locality 50-10), and are deposited in the type collection of the Bureau of Economic Geology, University of Texas, Austin, Texas (numbers 19442, 19445, 19446, 19447, 19448, 19450). Another collection studied for this paper is from one-half mile below Tom Miller dam, high in the bluff on the southwest side of the Colorado River (locality 49-61, number 19452, Bureau of Economic Geology, Austin, Texas). Cragin (1893) mentions that Prof. Brown had made a collection from Deep Eddy bluff (locality 50-10), which collection was available to him for study. Although without Cragin's designation it is presumptuous to designate individuals in the Brown collection as syntypes, by his own admission they are part of the suite of fossils that made up his impression of the species. Many individuals from the Brown collection were utilized in the present study, and are deposited in the Bureau of Economic Geology, Austin, Texas, numbers 19444, 19449, and 19451.

Collections made by Carl Chelf and now deposited with the Texas Memorial Museum, Austin, Texas, were also made available to the writer. These collections are from Deep Eddy bluff (accession number 1097, locality 50-11) and from Barton Creek (accession number 1098, locality 50-11).

Nerinea pellucida Cragin has also been found 6 miles northeast of Kerrville, Kerr County, Texas (reported by Stanton, 1947), from the Strohacker ranch 10 miles southwest of Kerrville (locality described by Ikins and Clabaugh, 1940), and questionably from the upper part of the Glen Rose formation in the vicinity of Granbury, Hood County, Texas (reported by Stanton,1947). Stanton further points out that the forms from the latter locality are all internal molds and were assigned by him to this species only on the basis of mensuration. The fallacies of identifying gastropod species on

the basis of mensuration of internal molds have already been pointed out. Except for the Hood County occurrence, all of the occurrences are in the Edwards limestone.

REFERENCES

ADKINS, W. S., 1928, Handbook of Texas Cretaceous fossils: Univ. of Texas Bull. 2838, 385 pp., 31 pls.

BURMA, BENJAMIN H., 1948, Studies in quantitative paleontology: I. Some aspects of the theory and practice of quantitative invertebrate paleontology: Journal Paleontology, vol. 22, pp. 725–761, 23 text figs.

COSSMANN, MAURICE, 1895–96a, Essais de Paléoconchologie comparée: prèmiere livraison, 159 pp., 79 pls., 1895; deuxième livraison, 179 pp., 7 pls., 1896, Paris, Comptoir géologique.

——, 1895–96b, Contribution a la Paléontologie Française des terrains jurassiques: Mèmoires de la Société Géologique de France, Paléontologie, Mèmoire 14, Tome V, fascicule IV and Tome VI, fascicule I, 167 pp., 6 pls.

——, 1898, Contribution a la Paléontologie Française des terrains jurassiques: Gastropodes Nérinées: Mèmoires de la Société Géologique de France, Paléontologie, Mèmoire 19, Tome VIII, fascicules I et II, 180 pp., 13 pls.

CRAGIN, F. W., 1893, Contributions to the invertebrate paleontology of the Texas Cretaceous: Geological Survey of Texas, 4th Ann. Report, for 1892, pp. 139–294, 46 pls.

DELPEY, GENEVIEVE, 1941, Gastéropodes marins. Paléontologie-Stratigraphie: Mèmoire de la Société Géologique de France, nouvelle série, no. 43, 114 pp., 28 pls.

DIETRICH, W. C., 1925, Gastropoda Mesozoica, Family Nerineidae: Fossilium Catalogus, I: Animalia: pars 31, pp. 1–164, W. Junk, Berlin.

IKINS, W. C., and CLABAUGH, S. E., 1940, Some fossils from the Edwards formation of Texas: Bull. Amer. Pal., vol. 26, no. 96, 22 pp., 2 pls.

OLSSON, A. A., 1934, Contributions to the paleontology of Northern Peru: The Cretaceous of the Amptape region: Bull. Amer. Pal., vol. 20, no. 69, 104 pp., 11 pls.

PIETTE, EDOUARD, 1856, Notice sur les grès d'Aiglemont et de Rimogne: Bulletin de la société géologique de France, 2nd ser., vol. 13, pp. 188–207, pl. 10.

——, 1857, Description des *Cerithium* enfonis dans les dèpots bathoniens de l'Aisne et des Ardennes: Bulletin de la société géologique de France, 2nd ser., vol. 14, pp. 544–562, pls. 5–8.

ROEMER, FERDINAND, 1888, Ueber eine durch die Haeufigkeit Hippuriten-artiger Chamiden ausgezeichnete Fauna der Oberturonen Kreide von Texas: Palaeontologischen Abhandlungen, vierter band, heft 4, pp. 281–296, 3 pls.

STANTON, T. W., 1947, Studies of some Comanche pelecypods and gastropods: U. S. Geol. Survey Prof. Paper 211, pp. 1–256, pls. 1–67.

WENZ, W., 1940, Gastropoda, Teil 4, Prosobranchia: in Schindewolf, Handbuch der Paläozoologie: Lieferung 6, Band 6, pp. 720–960, il.

WHITE, C. A., 1884, On Mesozoic fossils: U. S. Geol. Survey Bull. 4, 36 pp., il.

ZITTEL, KARL A. VON, 1913, Textbook of Paleontology: English edition, edited by Charles R. Eastman, 2nd edition, 839 pp., 1594 figs. London, Macmillan and Co.

MANUSCRIPT RECEIVED NOVEMBER 27, 1951

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 829–831, 1 TEXT FIG. SEPTEMBER 1952

STRUCTURE AND PALEONTOLOGICAL SIGNIFICANCE OF THE ORAL APPARATUS OF THE FORAMINIFEROID *GROMIA OVIFORMIS* DUJARDIN

ZACH M. ARNOLD
Museum of Paleontology, University of California, Berkeley

ABSTRACT—A rather complex oral apparatus is described in the testate protozoan *Gromia oviformis*. Desiccation experiments indicate that at least one portion of the structure, the tubuliferous ring, might be capable of preservation and subsequent recognition in the fossil record. The discovery of such identifiable remains would probably aid in the clarification of certain distributional and phylogenetic problems in which this and related primitive Foraminifera play a significant role.

THE genus *Gromia*, originally described by Dujardin (1835), is generally considered to be a primitive foraminiferan or at least within the ancestral testate complex from which the true Foraminifera have arisen. The genotype, *Gromia oviformis*, is probably the best known species within the rather poorly characterized genus, and is most certainly a form which should be studied in any attempt to relate the Foraminifera to the Testacea in an evolutionary lineage. Because of its similarities to both groups, the species has been shifted from one to the other by the taxonomist, and a permanent resting place probably will not be found for it until many of the details of the organism's protoplasmic organization, nuclear behaviour, life cycle and, possibly, paleontological record are known.

Gromia oviformis is known to occur in appreciable numbers throughout most of the coastal waters of the British Isles and western Europe. It has only recently (Arnold, 1951) been reported from American waters, but is now known to range over at least 400 miles of the California coast. Further study will undoubtedly extend this range in the Pacific waters of North America. The occurrence of a European species in California waters, with no records from intervening seas, has prompted this examination of the species and the evaluation of its "paleontological potential." It is hoped that the fossil record might eventually be consulted for evidence of the routes of dispersion and migration followed by the species in past times.

If this were an arenaceous or calcareous foraminiferan its past distribution would most probably be well known, since its large size would make it a conspicuous element of almost any protozoan fauna. Unfortunately, however, the creature is covered with a rather unimpressive, paleontologically ephemeral organic test, and most workers have not bothered to look for it in fossil sediments. Terquem (1866) apologetically assigned some white, translucent platelets from the Jurassic of France to the genus, erecting the species *liasica* to contain the unlikely enigmas; no other fossil record of the genus exists. The basis for Terquem's generic assigment is very tenuous, and it soon becomes obvious to anyone familiar with the genus that the recognition of any of its species in the fossil record would require the use of more definitive features than size, color, and over-all shape, since all of these would show drastic changes after the organism's death.

During the course of this study a structure has been found which will not only aid in the characterization and identification of the living organism, but which may eventually be used to recognize and identify fossil remains of the species. Experimental desiccation has shown that the structures to be described are recognizable in favorably oriented specimens and suggests that the test, with its definitive structures, has the potentiality of becoming fossilized.

Gromia oviformis, as excellently described by Jepps (1926), reaches a size of 3 mm. in diameter and is usually a brownish to greyish sphere with a transparent, colorless organic test. The mouth opening is sur-

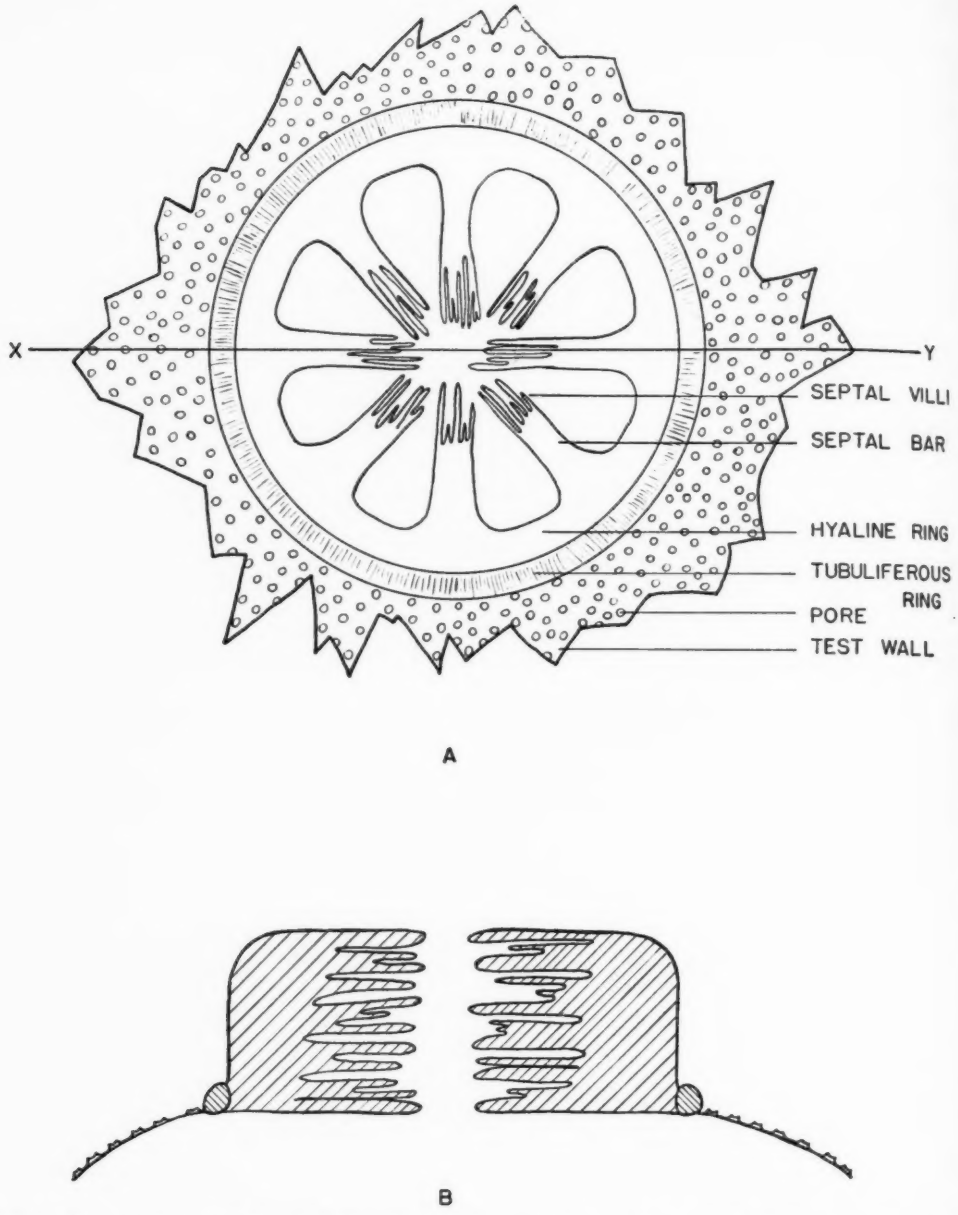


FIG. *1*—Oral apparatus of *Gromia oviformis*. A, diagrammatic sketch of mouth dissected from animal. B, vertical section through mouth at X–Y. Approximately 100×.

rounded by a transparent collar which typically protrudes into and is completely covered by a mass of debris, food and protoplasm.

Most biologists have studied serial sections of this organism and have failed to dissect the entire oral region from the test for detailed examination. By using

rather simple techniques and equipment it is possible to remove the circumoral portion and examine it under a microscope with reflected or transmitted light. Such a study has revealed morphological complexities which have not been previously described.

The oral apparatus consists, as seen in figure 1, of a tubule-bearing ring lying at the base of and circumscribing a hyaline ring, which forms the most conspicuous portion of the collar. Radiating inward from the hyaline ring are numbers of septal bars which frequently become villiform toward their free ends. The average over-all diameter of the mouth structure of mature individuals is from one-half to one millimeter.

The tubuliferous ring appears to be formed by the enrollment of the test wall. Although under low power the tubules seem to be simple striations, their tubular nature becomes apparent with an increase in magnification. By drying a preparation in air and mounting in thin xylol-balsam, bubbles of air are trapped within the tubules, a conclusive demonstration of their true nature.

The hyaline ring shows considerable variation in height and in the number of septal bars radiating from it. The ring and bars appear to be highly flexible. The total number of bars per individual has been observed to vary from 9 to 21. Although in some preparations there is no evidence of digitation at the free ends of the septal bars, most specimens show numerous villi or digits. The villi are irregular in length and shape and are so flexible as to be almost completely at the mercy of the materials which are strained through them during the normal feeding activities of the animal.

Although the function of the oral apparatus is not completely understood it seems likely that the organism relies heavily upon the villi and bars for anchorage to its substratum. The attachment effected is often so firm that the animal is torn to bits before its oral grasp can be broken by an external force. The presence of this species in the strong currents and waves of the Pacific intertidal areas attests to the efficacy of the structure as an attachment organelle.

In an effort to determine the fate of the test of *Gromia oviformis* after death several hundred animals were allowed to die under various laboratory conditions. In most cases the organic tests remained intact and easily recognized. After subsequent desiccation from evaporating distilled or sea water there was generally a slight reddening of the contained protoplasm and shrinkage of the entire organism. The amount of shrinkage and creasing varied with the individual, turgid forms showing less postmortem shrinkage than animals which were rather loosely filled with protoplasm. Many of the dried specimens looked like the nondescript pyritized globules so frequently encountered in micropaleontological samples, and it would be exceedingly difficult to identify such remains—even to genus—on the basis of shape, color and size alone.

The tubuliferous ring of the oral apparatus remained quite distinct and recognizable in several of the dried specimens, however, and it seems to offer the hope of a clue to the identification of the animal's fossil remains. The other mouth parts have not been recognized in dried specimens, but the tubuliferous ring alone is a sufficiently distinctive basis for a specific determination.

These observations and experiments indicate that the possibility for the eventual recovery and recognition of favorably preserved *Gromia oviformis* in the fossil record does exist. If identifiable remains are ever found it may be possible to explain some of the genus' distributional problems and the phylogenetic relationships between the Testacea and Foraminifera.

MANUSCRIPT RECEIVED JANUARY 23, 1952

REFERENCES

ARNOLD, Z. M., Occurrence of *Gromia oviformis* Dujardin in California: Wasman Journal of Biology, vol. 9, 1951, pp. 351–353.

DUJARDIN, F., 1835, Récherches sur les organismes inférieurs: Ann. Sci. Nat. Paris, sér. 2, vol. 4 (Zoology), pp. 343–377.

JEPPS, M. W., 1926, Contribution to the study of *Gromia oviformis* Dujardin: Quart. Journ. Micro. Sci., vol. 70, pp. 701–719.

TERQUEM, O., 1866, Cinquième mémoire sur les foraminifères du Lias des départements de la Moselle, de la Côte-d' Or et de l'Indre, avec un aperçu stratigraphique et pétrologique des environs de Nohant. Metz, Lorette, pp. 402, 453.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 832–840, PLS. 122–124, 4 TEXT FIGS., SEPTEMBER 1952

REVISION OF THE PENNSYLVANIAN AND PERMIAN FOOTPRINTS *LIMNOPUS*, *ALLOPUS* AND *BAROPUS*

DONALD BAIRD
University of Cincinnati Museum

ABSTRACT—A study of the types indicates that the genera *Limnopus*, *Allopus*, and *Baropus* Marsh, footprints of labyrinthodont amphibians, are synonymous. The types of *Limnopus vagus* Marsh (the type species) and *Limnopus* [*Allopus*] *littoralis* (Marsh) [=*Baropus lentus* Marsh] from the Upper Pennsylvanian of Kansas are redescribed and refigured; also the type and new material of *Limnopus* [*Baropus*] *waynesburgensis* (Tilton) from the Dunkard Permian of West Virginia.

Generic reassignments of four other species are discussed. *Limnopus? coloradensis* Henderson has been assigned by Gilmore to *Laoporus; Allopus? arizonae* Gilmore is here assigned to *Baropezia*, and *Baropus coconinoensis* Gilmore to *Baropezia eakini* Gilmore; *Baropus hainesi* Carman is made the type species of a new genus, *Megabaropus*.

The analyses of footprint morphology are based on composites of outlines printed direct from latex molds of the types; this method is an innovation in ichnologic technique.

FOREWORD

THIS study developed as an outgrowth of research on the University of Cincinnati Museum's topotype trackway of *Baropus hainesi* Carman, in which are preserved details necessitating a redescription of the species. Comparison with plastotypes furnished by the Yale Peabody Museum of Natural History soon showed *B. hainesi* to be non-congeneric with *Baropus* Marsh; however the synonymy of the latter genus with *Limnopus* and *Allopus* has taken precedence over the original project. Full discussion of *B. hainesi* and other ichnites from the Pennsylvanian of Ohio is therefore reserved for later publication.

This revision was made possible only through the cooperation of many scientists. I am particularly indebted to Carl O. Dunbar and Joseph T. Gregory of the Yale Peabody Museum, to C. L. Gazin and David H. Dunkle of the U. S. National Museum, and to M. G. Mehl of the University of Missouri for furnishing plastotypes; to J. Ernest Carman of Ohio State University, Ralph W. Whipple of Marietta College, and Aureal T. Cross of the University of West Virginia for assistance in molding types; and to Herbert Alexander for molding the Marietta specimen of *Limnopus waynesburgensis*. Walter H. Schoewe, Robert W. Wilson, and Warren O. Thompson furnished advice on stratigraphic problems, and Maxine L. Abbott made the paleobotanical determinations. Kenneth E. Caster's critical reading of the manuscript is gratefully acknowledged.

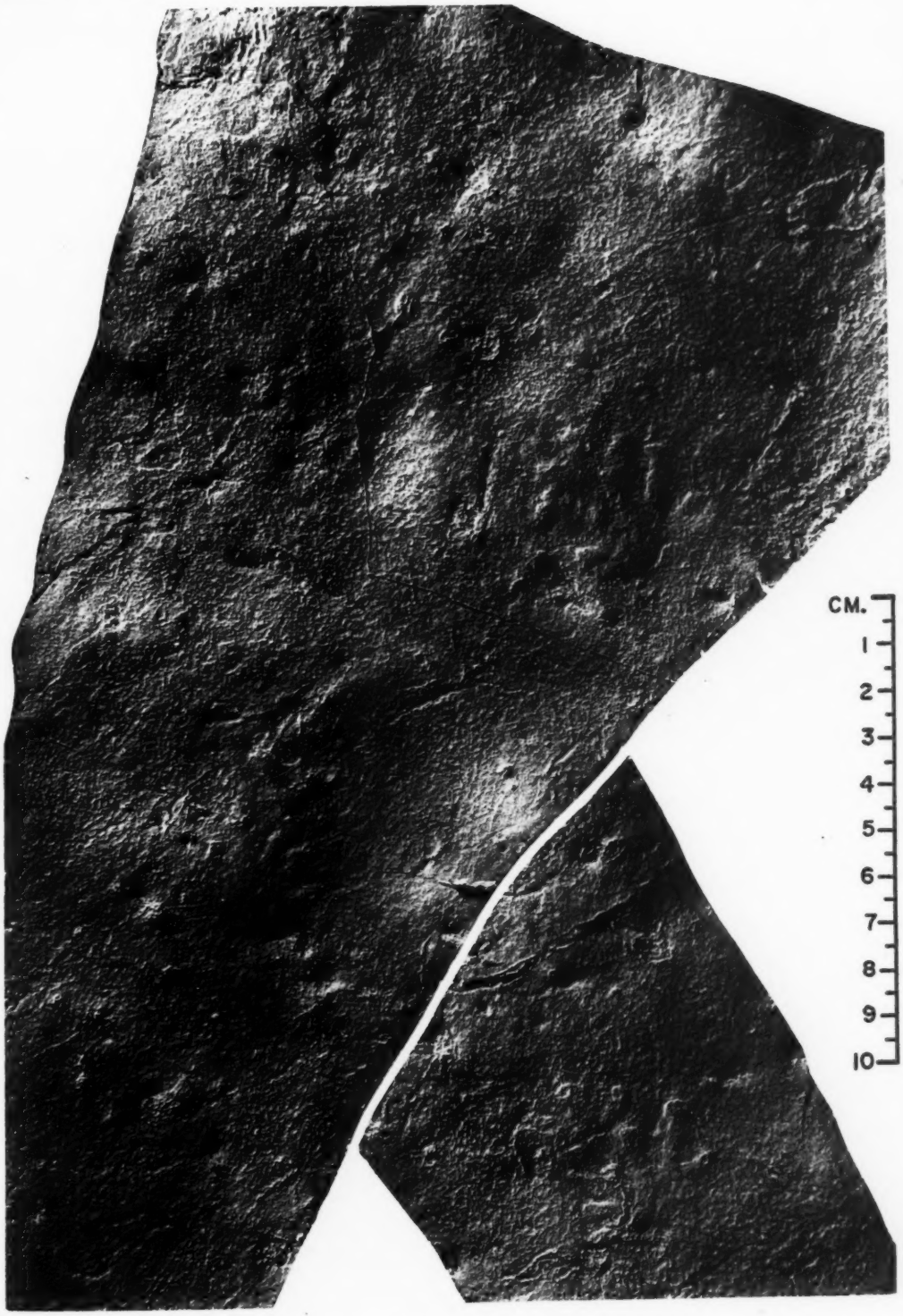
Plate 123 is a Yale Peabody Museum photograph. All other photographs were made by William B. Macke, and line drawings by the author.

TECHNIQUES

Many of the errors in ichnological literature can be traced to inadequate or inaccurate figuring of the types. The soundest basis for referring a new species to an established genus is a comparison with the hypodigm; however, the dissemination of types among scores of institutions makes first-hand examination and comparison difficult, and the bulk and fragility of most foot-

EXPLANATION OF PLATE 122

Limnopus vagus Marsh, type, Yale Peabody Museum no. 532. Trackway reconstructed from latex molds of two fragments. (p. 835)



Baird, Pennsylvanian and Permian footprints

Baird, Pennsylvanian and Permian footprints

print specimens limits the lending of type materials for study. Thus in practice, comparisons must ordinarily be made not with the types themselves but with the literature. As many of the early footprint types have never been photographed, subsequent students must rely on the accuracy of woodcuts, engravings, and lithographs—media in which the facts may be considerably modified by subjective interpretation.

Obviously a method of producing minutely accurate, portable and unbreakable, permanent plastotypes should prove of great value to the systematic study of footprints. Just such a method, the latex molding technique developed for scientific use by Ottmar F. von Fuehrer at the Carnegie Museum (see Baird, 1951), has been applied here: this study is based almost entirely on latex molds either made by me or furnished by cooperating institutions. All the photographs except Plate 123 were made from black-surface molds grayed with ammonium chloride.

Outlines of the tracks were inked directly onto the rubber and transferred to damp paper, a refinement of the direct printing method sometimes employed by Hitchcock (1858, p. 51). The imprints could thus be compared directly by superimposing the transferred outlines over a bright light. Differences caused by variations in impression were revealed by comparison of the successive imprints of each foot, and composite outlines for each of the four feet were drawn. Comparison of the outlines of the left and right feet usually showed pronounced intra-individual differences in morphology which had to be considered in the preparation of a composite outline for the species. This method of analysis, an innovation in ichnologic technique, serves to minimize the errors which may arise when a single set of impressions rather than the entire trackway is used as a basis for description.

The terminology of trackway measurements followed in this paper is that proposed by Peabody (1948, pp. 297–299), and requires no further explanation than the graphic definitions given in figure 1. A

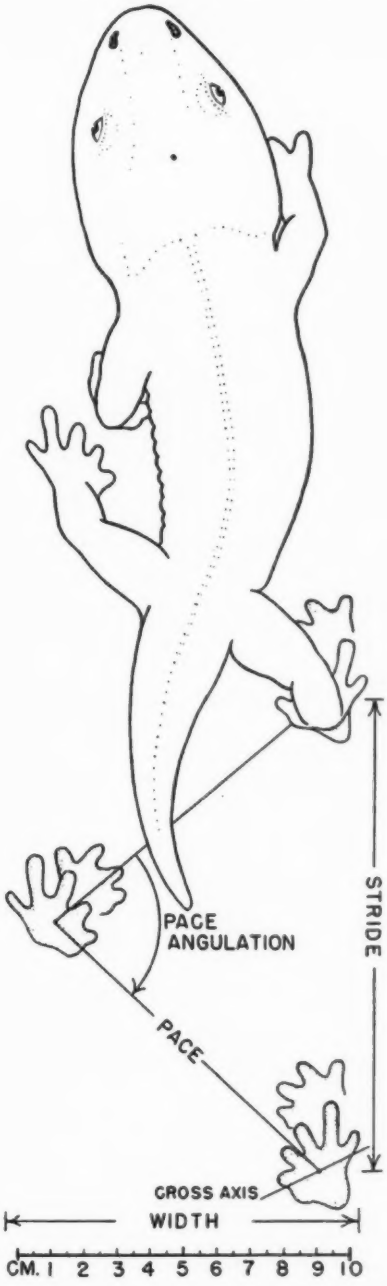


FIG. *1*—Trackway of *Limnopus vagus*, ×0.44, with hypothetical restoration of the amphibian in walking pose.

EXPLANATION OF PLATE 123

Limnopus littoralis (Marsh), Yale Peabody Museum no. 405 (type of *Baropus lentus*). Yale photograph of the best preserved trackway of this species. (p. 836)

method of determining the approximate distance between the shoulders and hips of a trackway-making amphibian or reptile is outlined here because it affords direct comparison of body proportions between trackway-makers and skeletons.

The distance between the glenoid fossa and the acetabulum can be determined with good accuracy if the trackway preserves one or more sets of four imprints in which the animal stood at a given time (see figure 1). Less accurate results can be obtained by extrapolation from an incomplete trackway. A point on the trackway midline halfway between the two carpi represents the approximate center of the glenoid axis, and a point halfway between the two tarsi similarly represents the center of the acetabular axis at the same stage in the cycle of locomotion. The gleno-acetabular distance measured between these two points is of course slightly less than the actual distance measured along the lateral curve of the spine.

HISTORICAL BACKGROUND

In 1873 B. F. Mudge noted reptilian footprints in the sandstone flagging of Kansas Avenue, Topeka. Tracing the flagstones to the Crane & Dood quarries near Osage (now Osage City), he discovered the remarkable Pennsylvanian footprint assemblage which may hereafter be called the Osage City faunule. The collection of 30 footprint-bearing slabs which Mudge had shipped to Manhattan, Kansas, was shortly afterward examined by O. C. Marsh and a part of it secured for Yale University. In 1874 Mudge published a detailed account of the occurrence and descriptions (without names) of four footprint species.

Just 20 years later Marsh (1894) published as an appendix in the American Journal of Science a cursory description of five ichnite genera from the Osage City collection. This study was apparently made in haste and without reference to Mudge's scholarly paper. In consequence Marsh overlooked entirely the largest, most common, and perhaps most unusual ichnite of the faunule (which remains undescribed to this day), and separated into two genera footprints which Mudge had correctly recognized as pertaining to a single species. The resulting confusion of nomenclature, augmented by subsequent reference of other species to the incorrectly defined Osage City genera, is the reason for this revision.

STRATIGRAPHY

As the horizon of the Osage City faunule cannot be determined with certainty today, Mudge's account (1874, reprint p. 71) of the geology takes on added significance:

> The flagging at the new quarry consists of four principal layers, respectively one and a half, two, three and four inches in thickness, interlaid usually by thin seams of soft shale. The flagging is fine-grained sandstone of close texture, coming out in slabs sometimes ten feet by twenty-five.
>
> At the old quarry, the layers are not so distinct. The slabs, as they are quarried, are frequently inclined to split in thin sheets, some of which are marked by footprints. The best of the smaller ones were thus obtained, giving a fine specimen of footprint and cast.
>
> The deposit is just above the middle of the coal measures, and about a dozen feet above the coal seam worked at Carbondale and Osage. The slabs or layers containing the footprints afford but few fossils, although there are numerous fucoidal impressions with ripple-marks. But immediately above and below the flagging, are calcareous strata containing abundant remains of the usual marine fossils of the period.

Walter H. Schoewe, an authority on the Osage City mining district, states in a letter dated April 6, 1951:

> Thus far we have been unable to locate the old quarry sites and thus cannot give you the exact stratigraphic horizon from which the specimen came. The only rocks which in any way approach flagging that I have seen occur in the Utopia limestone, the uppermost member of the Howard limestone formation. These rocks occur from 15 to 20 feet above the Nodaway coal and are interbedded with shales. The rocks are platy, dense, smooth, and calcareous and are over and underlain by fossiliferous limestones.
>
> According to Mudge's description the Utopia rocks seen in Sec. 15, T 17 S, R 14 E, about 4 miles due south of the west line of Osage City seem to best fit the bill.

As the Nodaway is unquestionably the coal seam involved, this assignment seems probable from the available evidence. Apparently the flagstone layers, a local development in the limestone member, have been largely removed and the quarries obliterated.

SYSTEMATIC DESCRIPTIONS

Genus LIMNOPUS Marsh, 1894

MARSH, O. C., 1894. Am. Jour. Sci., 3rd ser., vol. 48, p. 82.

Type species: *Limnopus vagus* Marsh, by monotypy.

Diagnosis.—Amphibian footprints, pace angulation 80°–85°, pes impressed close behind manus, digits terminally rounded. *Manus:* tetradactyl with short, broad digits in order of increasing length I-II-III, IV subequal to II; digits I-III directed obliquely toward midline of trackway; circular pad on metacarpal I; posterior margin of palm concave or undefined. *Pes:* pentadactyl but often lacking digit V impression; digits in order of increasing length I-II-III-IV, V subequal to II; prominent rounded pad on metatarsal I; posterior margin of sole broadly rounded with U-shaped posterolateral heel occasionally impressing.

LIMNOPUS VAGUS Marsh, 1894, p. 82
Plate 122; text figures 1, 2

Type.—Yale Peabody Museum no. 532, a trackway (now broken). Collected by B. F. Mudge, 1873. This is the only reported specimen.

Horizon.—Upper Pennsylvanian, Virgil series, Wabaunsee group, flaggy sandstones about 12 feet above Nodaway coal. Probably Utopia limestone member of Howard limestone formation.

Locality.—Crane & Dodd's old quarry near Osage City, Osage County, Kansas.

Diagnosis.—Pes slightly longer than wide (heel excluded), toed in with cross axis of sole at 65° angle with midline of trackway. Pes impressed posterior and somewhat lateral to manus, occasionally overlapping it slightly. Measurements in Table 1.

This is the smallest species, only a quarter the linear size of the other two. Whether the tracks were made by an adult or a juvenile amphibian cannot be determined, but the clear impression at every step of pes digit V (which impresses only occasionally in the larger species) suggests a more cartilaginous, juvenile foot. On the larger slab in Plate 122 the right heel impresses faintly while the left pes shows a clearly defined sole but no heel; apparently the recording surface sloped toward the animal's right, i.e. toward the left of the photograph. The tip of the left pes digit II is missing, probably as the result of injury, and the left pes is 2 mm. wider than the right. As the opposite pedes differ slightly in form, the outline in figure 2 is a composite. Mudge recognized this species and its similarity to the following one, but considered the material inadequate for characterization.

The gleno-acetabular length of the am-

TABLE 1.—COMPARATIVE AVERAGE MEASUREMENTS OF *Limnopus* IN MILLIMETERS. LENGTH AND WIDTH OF FEET ARE MEASURED IN REFERENCE TO MIDLINE OF TRACKWAY. SIZE RANGE FOR THE TYPE AND REFERRED SPECIMENS OF *L. littoralis* IS INDICATED IN PARENTHESES

	L. vagus	*L. littoralis*	*L. waynesburgensis*
Stride	140	540	—
Pace	110	400	—
Trackway width	110	425	—
Pace angulation	81°	85°	—
MANUS			
Length	21	96 (93–98)	95
Width	20	106 (105–107)	98
Digit I	4–5	24 (23–25)	21
II	7	32 (29–35)	28
III	8	37 (35–38)	37
IV	7	35 (33–36)	30
PES			
Length	30	113, 122	113
Length with heel	33	est. 135	est. 135
Width	27	120, 130	110
Digit I	4	23 (22–24)	22
II	7	37 (35–40)	35
III	11	49 (47–51)	44
IV	14	63 (62–67)	54
V	ca. 9	ca. 47	ca. 32

phibian which made these footprints is calculated at 90 mm., so the total body length was probably 240 to 270 mm. The hypothetical restoration in figure 1 is based on the rhachitome *Micropholis* which, though much younger geologically than the tracks, agrees fairly well with them in pedal morphology and trackway proportions. The absence of any body or tail drag in

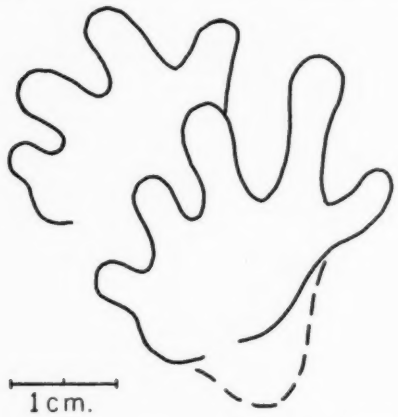


FIG. 2—*Limnopus vagus*, right manus-pes set, ×1.4. Composite outline based on the type. Dashed line shows occasionally impressing heel.

Limnopus trackways is further evicence of a relatively short-tailed, high-standing amphibian of the rhachitomous type.

LIMNOPUS LITTORALIS (Marsh)

Plates 123, 124, figures 1–3; text figure 3

Allopus littoralis Marsh, 1894, p. 83.
Baropus lentus Marsh, 1894, p. 83. Junior synonym by intra-page precedence.

Type.—Yale Peabody Museum no. 207, a slab with parts of two trackways, collected by B. F. Mudge, 1873.

Hypodigm.—The type; Yale Peabody Museum no. 405 (type of *Baropus lentus*), a trackway of five manus-pes sets; uncatalogued YPM specimen, a partial right set; all collected by Mudge. University of Missouri no. 593 V.P., a left set; collector unknown.

Horizon.—Upper Pennsylvanian, Virgil series, Wabaunsee group, flaggy sandstones about 12 feet above Nodaway coal. Probably Utopia limestone member of Howard limestone formation.

Locality.—Crane & Dodd's old quarry near Osage City, Osage County, Kansas.

Diagnosis.—Pes slightly wider than long (heel excluded); cross axis of sole perpendicular to midline of trackway. Approximately four times as large as *L. vagus*; measurements in Table 1.

As Mudge's description (1874, reprint p. 73) of this form was based on much more material than is available today, a quotation is pertinent:

> These tracks are very clear in the outline of the front toes, but the heel is obscure. The outline of the foot appears to have been four and a half to five inches wide, and in length five and a half. The length of the stride is from twenty-one to twenty-two inches. The hind footprint usually covers the heel of the fore foot. We obtained both the true track and the cast. The width of the trackway is eleven and twelve inches, measuring from center to center. The front foot has four toes, the hind foot five, the fifth being short and perhaps rudimentary. The footprint shows that the animal in walking rested his weight mostly on the toes, as these are strongly and clearly impressed, while the heel can be traced with difficulty. In several instances the wrinkle of the skin could be seen. No trace of a claw was visible .... We procured twelve slabs of this species, and a few single tracks. From four to sixteen footprints were found on each slab, numbering in all about one hundred.

The superficiality of Marsh's study is indicated by the fact that he mistook a conical raindrop impression for the first manus digit of *Allopus littoralis* (see Plate 124, figure 1) and overlooked the deep imprint of the fifth pes digit. *Allopus* was thus defined as having a pentadactyl manus and a tetradactyl pes although the reverse is true. In describing *Baropus lentus* Marsh again overlooked the fifth pes digit, which shows clearly in the first left set of the type (see Plate 123).

The trackway of *Limnopus littoralis* indicates a large amphibian with a glenoacetabular length calculated at 390 mm. The type pes impression (Plate 124, figure 1) is not a typical record of the species, for the foot was dragged 30 mm. outward and backward before impressing fully and was then rotated several degrees in the soft mud as the animal moved forward. Measurements of this outsized imprint are recorded in Table 1 as maxima for the species.

Branson and Mehl (1932, pp. 388–391) correctly recorded the presence of a fifth

pes digit in their description of the University of Missouri specimen. Through misguided retouching of the photograph, however, the round metacarpal pad was transformed into Marsh's imaginary first digit, manus digits I and II were extended to include their drag marks, and the divergence of pes digit V was exaggerated. This specimen has a narrower pes with more closely appressed digits than the Yale types, but this small difference in a single imprint would seem to have no taxonomic significance.

The Osage City faunule also includes a small amphibian trackway showing a tail trace, *Nanopus caudatus* Marsh; a lacertoid reptile trackway, *Dromopus agilis* Marsh; and trackways of an undescribed reptilian form with apparently bipedal tendencies. Discussions of the nature and affinities of these genera are in manuscript.

LIMNOPUS WAYNESBURGENSIS (Tilton)
Plate 124, figure 4; text figure 4

Baropus waynesburgensis TILTON, .1931, Geol. Soc. America Bull., vol. 42, p. 551.

Type.—University of West Virginia Geology Museum no. 69, Permian no. 8 A–E, five isolated sets from one trackway. Collected by Harold Riggs, 1925; described and figured without name by Tilton (1926, pp. 386–391).

Hypodigm.—The type; a right manus-pes set, Marietta College Geology Department, Marietta, Ohio. The latter specimen was collected by Stafford Happ and Herbert Alexander, 1930, and described without name by them (1934).

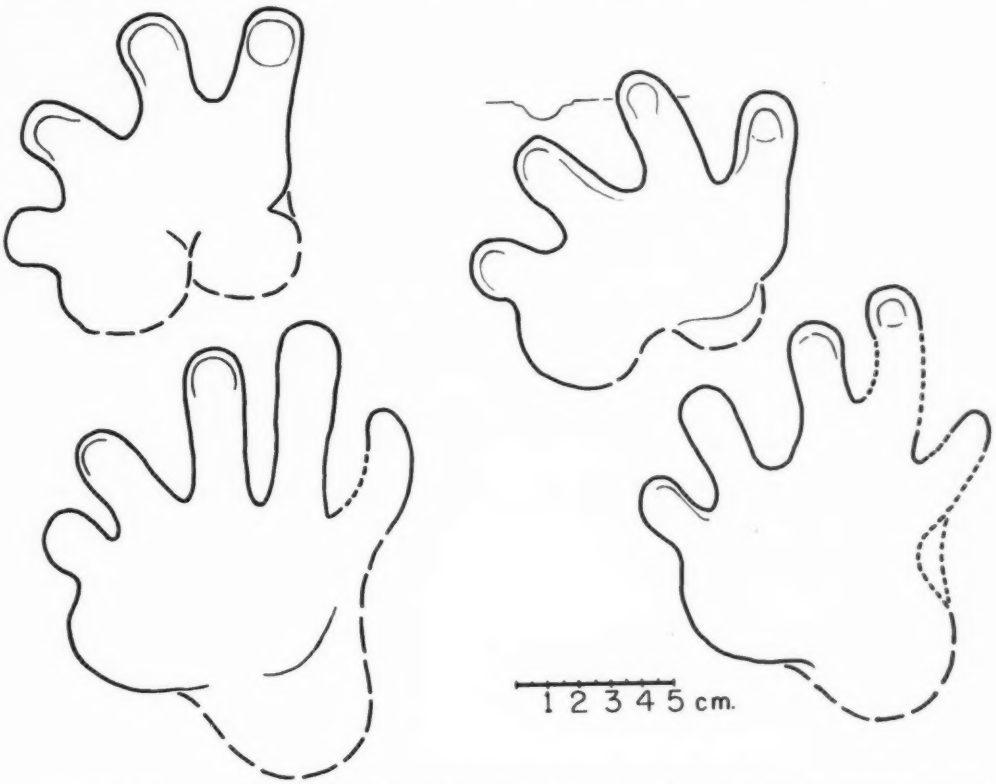


FIG. 3—(left *Limnopus littoralis*. FIG. 4—(right) *Limnopus waynesburgensis*. Right manus-pes sets, ×0.42. Composite outlines based on entire hypodigms. Dotted lines restored, dashed lines show occasionally impressing areas. Cross-section shows flanged digit-tip impressions of *L. waynesburgensis*.

Horizon.—Lower Permian, Dunkard series. Waynesburg sandstone 19.5 feet below the top (for the type). Member tentatively correlated with the lower Marietta sandstone (for the Marietta specimen).

Locality.—Bluff along Middle Island Creek 5.7 miles northwest from nearest bridge at West Union, Doddridge County, West Virginia (for the type). Grindstone quarry on L. E. Miller farm, south side of Little Sandy Creek near Sherman, Jackson County, West Virginia (for the Marietta specimen).

Diagnosis.—Pes slightly wider than long (heel excluded); basal half of pes digit III joined to IV. Measurements in Table 1.

This species is very similar in size and general form to *Limnopus littoralis*. The characteristic union of the third and fourth pes digits at their base is exhibited only faintly in the type, because of incomplete impression of the lateral border, but shows clearly in the Marietta specimen (Plate 124, figure 4). Tissues connecting the two digits were apparently firm and thick rather than web-like. In this Permian species the fifth pes digit impresses faintly or not at all, and appears to be in the process of reduction.

A shallow flange, shown in section in figure 4, surrounds the central toe-tip depressions especially in the manus: this may be a structural feature rather than an impression phenomenon. In the Marietta specimen this flange is concealed by filling of the footprint depressions with silt and small cylindrical bodies which are probably arthropod excreta.

No exact trackway measurements are available for this species, as the impression and counterpart slabs of the type trackway were broken by workmen soon after discovery and only the isolated manus-pes sets were saved. Harold Riggs, the collector, stated that the left and right lines of prints were a foot apart and the stride was 18 inches from a print on one side to the next similar print on the same side. These measurements conform roughly to the generic trackway pattern, but since Riggs' points of reference for measurements are unknown, no exact comparison with the other species can be made.

In July 1950 I visited the type locality but found no trace of footprints. Impressions of ferns collected in the roadside talus and presumably pene-contemporaneous with the footprints were identified by Maxine L. Abbott as *Asterotheca [Pecopteris] arborescens* Schlotheim and *Alethopteris crassa* Lesquereux. The only other footprints known from the Waynesburg sandstone were found some 15 air miles to the southwest near Berea, Ritchie County, West Virginia, near the base of the formation and therefore some 35 feet lower stratigraphically. These tracks, *Dimetropus berea* (Tilton), were apparently made by a large pelycosaurian reptile such as *Edaphosaurus*.

No further *Limnopus* material could be found in the grindstone quarry where the Marietta specimen was collected. A slab of footprints from the same quarry, figured by Happ and Alexander (1934), indicates a small animal of doubtful affinities. The individual prints are 6 to 7 cm. long and 7 to 8 cm. wide with digits up to 4 cm. long, possibly clawed. Two trackway patterns are shown. In one the stride is 40 cm., the pace angulation is 90°, and the manus falls beside the opposite pes to make a rectangular pattern. In the other the stride is 48 cm., the pace angulation is 105°, and the pes falls 15 cm. behind the manus in more normal fashion. This slab has unfortunately been lost and no adequately preserved specimens could be found in the quarry, so nothing can at present be added about the fauna associated with *Limnopus waynesburgensis*.

GENERIC REASSIGNMENTS

The high incidence of questionably and improperly referred species in ichnology is largely due to the obscurity and variability of most footprint records. Contributing causes are the inadequacy of many early descriptions and figures and the fact that much descriptive work has been done by amateurs. As a result the nomenclature and taxonomy are so confused and changeable as to prejudice the position of ichnology as a legitimate paleontological science.

The redescription and photographic reillustration of early types, and a wider exchange of plastotypes, are prerequisite to the efficient progress of ichnology. Adequate photographs are essential. Outline drawings, woodcuts, and lithographs, though better than no figure at all, are too subjective to be truly scientific; retouched

photographs may falsify the evidence while retaining the appearance of truth.

Four species which have been improperly referred to *Limnopus*, *Allopus*, and *Baropus* are discussed below, with notes on their probable affinities.

LIMNOPUS? COLORADENSIS Henderson

Henderson (1924, p. 228) proposed this name for trackways from the Lyons sandstone, Middle Permian (Pennsylvanian, auct.) of Lyons, Colorado. Gilmore (1926, pp. 16–18, pl. 7) has redescribed the species as *Laoporus coloradoensis* [sic] (Henderson), and reports its occurrence in the Permian Coconino sandstone of the Grand Canyon National Park, Arizona.

ALLOPUS? ARIZONAE Gilmore

This species, described by Gilmore (1926, pp. 29–31; pl. 11, fig. 2), was collected 150 feet above the base of the Coconino sandstone on Hermit Trail in Hermit Basin, Grand Canyon National Park. The type (U. S. National Museum no. 11,132, cited errore by Gilmore throughout as no. 11,123) is an exceedingly obscure trackway partially obliterated by a second trackway. The animal walked downhill, thrusting its toes deep into the sand, and as each foot was withdrawn the sand collapsed into the toe impressions. Each fall of the pes forced sand into the manus imprint just behind it. As a result the exact pedal morphology of the species cannot be determined from the type trackway, though the pes appears to be pentadactyl and the manus at least tetradactyl. Fairly accurate trackway measurements can be made:

Stride: 520 to 560 mm., average of six, 530 mm. *Pace:* 340 to 380 mm., average of six, 350 mm. *Trackway width:* about 330 mm. *Pace angulation:* 99° to 105°, average of four, 102°. Reference point is the base of pes digit III, the deepest point of the imprint.

This species differs from *Limnopus* as redefined in the pronounced toe-in of the pes, in setting pes ahead of manus imprint, in shortness of digits and width of sole, and in pace angulation. In all these characters it agrees with the genus *Baropezia* Matthew (1903, p. 105). As redefined by the describer (1905, pp. 99–102) this genus has four digits on the pes and three on the manus, with the possibility of an additional digit on each. As the manus imprints are incomplete the digital formula of the type species *B. sydnensis* may perhaps be 5-5 as it is in *B. eakini* Gilmore (1926, pp. 18–23). A definite assignment must await restudy of the type species, but in view of the similarities it is proposed that the specific name of the Coconino form be amended provisionally to *Baropezia arizonae* (Gilmore). This species may be distinguished from its contemporary *B. eakini* by the shortness of pes digit I and the semicircular instead of subtriangular outline of the pes.

BAROPUS COCONINOENSIS Gilmore

This species was described by Gilmore (1927, pp. 23–26, pl. 7) as occurring about 125 feet above the base of the Coconino sandstone in the Hermit Trail quarry. After lengthy study of the types I can find no significant morphologic difference between it and *Baropezia eakini*. On the basis of a single partial trackway *Baropus coconinoensis* is three times as large, has a slightly shorter stride in proportion to pes length, and places the pes somewhat closer to the posterior than to the anterior manus imprint.

As *Baropezia eakini* is based on two trackways of the same individual and *Baropus coconinoensis* on two consecutive left manus-pes sets, the range of morphologic variation for neither species can be determined; the size difference between them could easily be ontogenetic. Greater differences in trackway pattern may be observed in the trails of a single Recent amphibian under different conditions of surface slope, temperature, physiological state, and motivation. Furthermore, the type individual of *Baropezia eakini* had a crippled right pes, so its trackway pattern may well be atypical for the species. These minor, questionable differences and the stratigraphic separation of about 25 feet seem insufficient grounds for considering *Baropus coconinoensis* as anything but a senior individual and junior synonym of *Baropezia eakini*.

MEGABAROPUS Baird, n. gen.

Type species: *Baropus hainesi* CARMAN, J. E., 1927, Geol. Soc. America Bull., vol. 38, pp. 386–388, pl. 11.

A redescription of this species, based on

excellent topotype material in the University of Cincinnati Museum and other collections, is in manuscript; therefore only a brief preliminary notice is necessary here. *Megabaropus* differs from *Limnopus* in having a pentadactyl manus and a pes with widely radiating digits more nearly equal in length, with a short digit V set well back on the sole. The palmar and plantar pads are distinct and characteristic.

Affinities of *Megabaropus* lie with *Parabaropus* Gilmore (1927, p. 53) from the Hermit Permian of the Grand Canyon National Park, Arizona, but it differs from that genus in the strong divarication of manus digit V and the absence of a prepollex-like projection posterior to digit I.

At least a dozen trackways of *Megabaropus hainesi* have been found on the E. R. Haines farm near Hackney, Center Township, Morgan County, Ohio, in association with footprints of *Dimetropus* n. sp. and a new species of *Dromopus*. The recording surfaces occur in a flaggy sandstone just below the Benwood limestone of the Monongahela series, Upper Pennsylvanian.

Footprints referred tentatively to *Baropus hainesi* have been described by Mitchell (1933) as occurring in the very base of the Conemaugh series just above the Upper Freeport coal in a mine at Senecaville, Guernsey County, Ohio. A restudy of these tracks, now in progress, indicates their distinctness from known Paleozoic footprint species.

BIBLIOGRAPHY

ANON., 1873, Footprints in the Middle Coal Measures at Osage in Kansas: Am. Jour. Sci., vol. 106, p. 228; reprinted from Kansas Commonwealth, Topeka, July 6, 1873.

BAIRD, DONALD, 1951, Latex molds in paleontology: Compass of Sigma Gamma Epsilon, vol. 28, no. 4, pp. 339–345.

BRANSON, E. B., and MEHL, M. G., 1932, Footprint records from the Paleozoic and Mesozoic of Missouri, Kansas, and Wyoming: Geol. Soc. America Bull., vol. 43, pp. 383–398, pl. 10.

CARMAN, J. E., 1927, Fossil footprints from the Pennsylvanian system in Ohio: Geol. Soc. America Bull., vol. 38, pp. 385–396, pls. 11–13.

GILMORE, C. W., 1926, Fossil footprints from the Grand Canyon: Smithsonian Misc. Coll., vol. 77, no. 9, 41 pp., 12 pls.

——, 1927, Fossil footprints from the Grand Canyon: second contribution: ibid., vol. 80, no. 3, 78 pp., 21 pls.

——, 1928, Fossil footprints from the Grand Canyon: third contribution: ibid., vol. 80, no. 8, 16 pp., 5 pls.

HAPP, STAFFORD, and ALEXANDER, HERBERT, 1934, Footprints from the Permian of West Virginia: Jour. Geol., vol. 42, pp. 753–755.

HENDERSON, JUNIUS, 1924, Footprints in Pennsylvanian sandstones of Colorado: Jour. Geol., vol. 32, pp. 226–229.

HITCHCOCK, EDWARD, 1858, Ichnology of New England. A report on the sandstone of the Connecticut Valley, especially its fossil footmarks. Boston, William White; 220 pp., 60 pls.

MARSH, O. C., 1894, Footprints of vertebrates in the Coal Measures of Kansas: Am. Jour. Sci. 3d ser., vol. 48, no. 283, pp. 81–84, pls. 2–3.

MATTHEW, G. F., 1903, New genera of batrachian footprints of the Carboniferous system in eastern Canada: Canadian Rec. Sci., vol. 9, pp. 99–111, 1 pl.

——, 1905, New species and a new genus of batrachian footprints of the Carboniferous system in eastern Canada: Royal Soc. Canada Proc. and Trans., 2d ser., vol. 10, sect. 4, pp. 77–121, pls. 1–6.

MITCHELL, R. H., 1933, Notes on another Pennsylvanian footprint from Ohio: Ohio Jour. Sci., vol. 33, pp. 48–49.

MOORE, R. C., 1949, Divisions of the Pennsylvanian system in Kansas: Kansas Geol. Surv. Bull. 83, 203 pp.

MUDGE, B. F., 1874, Recent discoveries of fossil footprints in Kansas: Kansas Acad. Sci. Trans., vol. 2, pp. 7–9; 1896 reprint, pp. 71–74.

PEABODY, F. E., 1948, Reptile and amphibian trackways from the Lower Triassic Moenkopi formation of Arizona and Utah: Univ. of Calif. Dept. Geol. Sci. Bull., vol. 27, pp. 295–468, pls. 23–45.

SCHAEFFER, BOBB, 1941, The morphological and functional evolution of the tarsus in amphibians and reptiles: Am. Mus. Nat. History Bull., vol. 78, pp. 395–472.

SCHOEWE, W. H., 1946, Coal resources of the Wabaunsee group in eastern Kansas: Kansas Geol. Surv. Bull. 63, 144 pp., map.

THOMPSON, W. O., 1949, Lyons sandstone of Colorado front range: Am. Assoc. Petroleum Geologists Bull., vol. 33, pp. 52–72.

TILTON, J. L., 1926, Permian vertebrates from West Virginia: Geol. Soc. America Bull., vol. 37, pp. 385–396, pl. 11.

——, 1931, Permian vertebrate tracks in West Virginia: ibid., vol. 42, pp. 547–556.

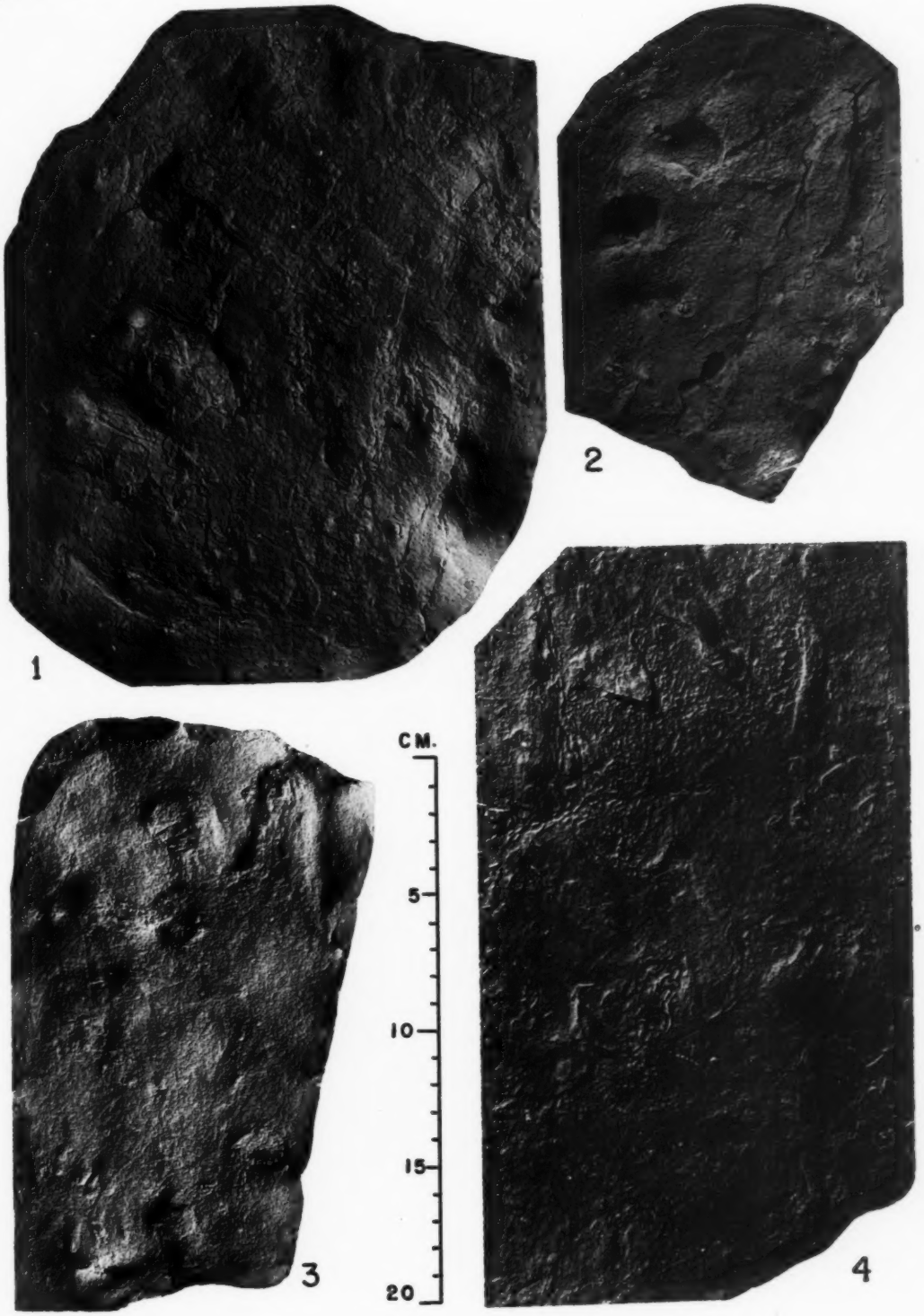
MANUSCRIPT RECEIVED MAY 16, 1951

EXPLANATION OF PLATE 124

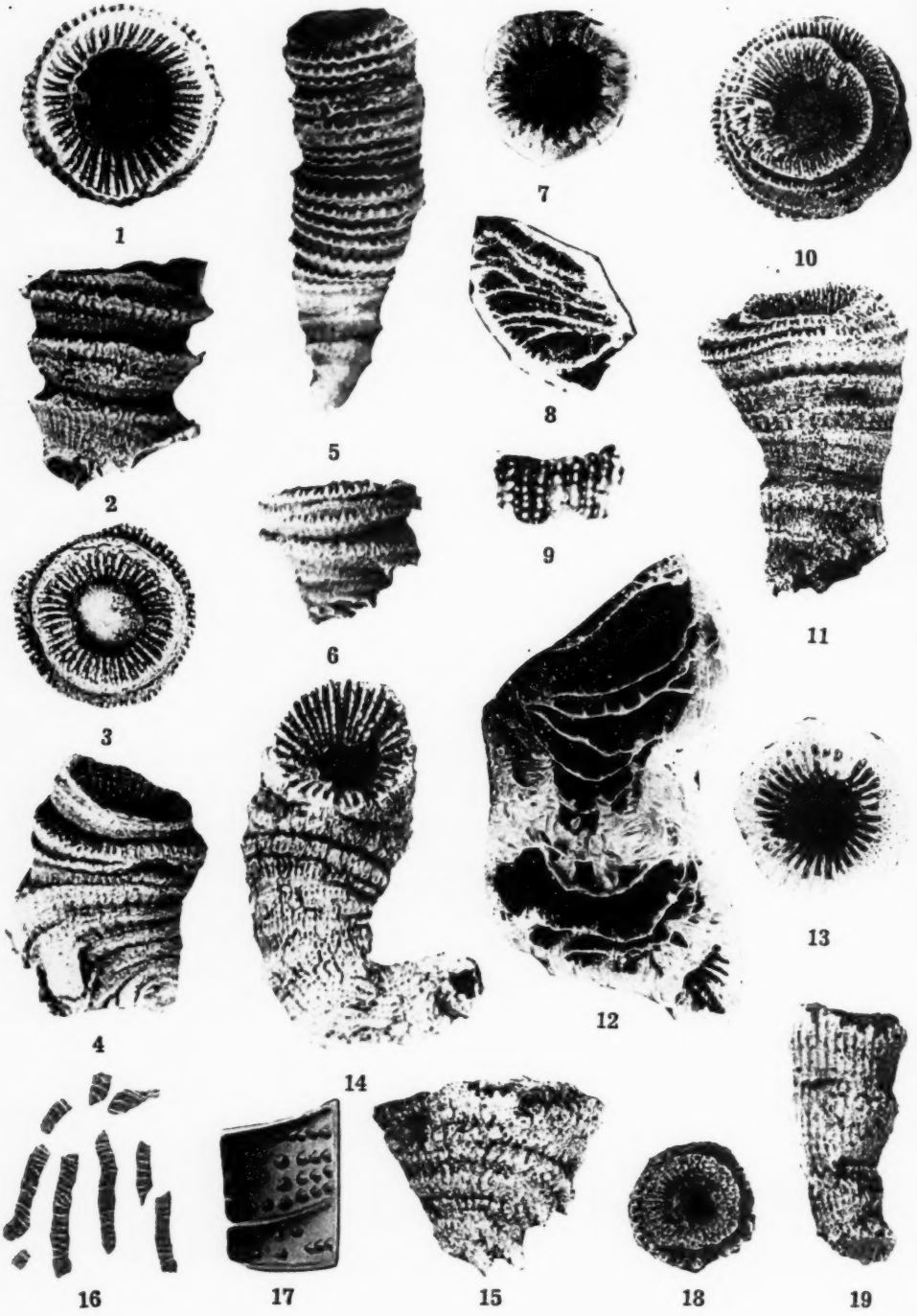
FIGS. *1–2—Limnopus littoralis* (Marsh), latex molds of sets from type slab, Yale Peabody Museum no. 207. (p. 836)

3—Limnopus littoralis, latex mold of uncatalogued Y.P.M. specimen from Mudge collection. (p. 836)

4—Limnopus waynesburgensis (Tilton), latex mold of Marietta College specimen. (p. 837)



Baird, Pennsylvanian and Permian footprints



Stumm, Silurian coral *Tryplasma*

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 841–843, PL. 125, SEPTEMBER 1952

SPECIES OF THE SILURIAN RUGOSE CORAL *TRYPLASMA* FROM NORTH AMERICA

ERWIN C. STUMM
Museum of Paleontology, University of Michigan, Ann Arbor

ABSTRACT—The Silurian rugose coral genus *Tryplasma* is a member of a cognate group in which the septa are composed of vertical series of spines. Several North American species formerly assigned to *Cyathophyllum*, *Aphyllostylus*, and *Amplexus* are found to be species of *Tryplasma*. Species of this genus are present in the Manistique dolomite of Michigan, the Hopkinton dolomite of Iowa, the Louisville limestone of Indiana and Kentucky, the Brownsport formation of Tennessee, the Keyser limestone of Maryland and Virginia, and the Stonewall limestone of Manitoba.

INTRODUCTION

SILURIAN rugose corals with acanthine septa are common in Europe, Asia, and Australia. In recent years the European forms have been studied by Wedekind (1927, pp. 25–32), and by Hill (1936, pp. 189–217). Australian forms were studied by Hill (1940, pp. 404–408). In this last publication Hill proposed the family name Rhabdocyclidae to include those Silurian rugose corals which possessed acanthine septa and lacked dissepiments. The more primitive discoid or patellate forms without tabulae such as *Porpites* and *Rhabdocyclus* are represented by several species in North America. These have been described by Bassler (1937, pp. 189–193). The more advanced forms which possess tabulae, most species of which can be referred to the genus *Tryplasma*, have long been recognized in European and Australian strata, but the North American species have been referred to *Amplexus*, *Charactophyllum*, or *Cyathophyllum* by previous workers.

The present paper recognizes the presence of four species of *Tryplasma* in Silurian strata of North America.

Phylum COELENTERATA
Class ANTHOZOA
Subclass TETRACORALLA
Family RHABDOCYCLIDAE Hill 1940

Diagnosis.—Rugose corals of which the simple forms may be discoid, patellate, or subcylindrical, and the compound forms weakly dendroid or phaceloid. Acanthine septa present in all forms. Complete tabulae characteristic of all but discoid or patellate species. Dissepiments absent in all forms.

EXPLANATION OF PLATE 125

FIGS. *1–9*—*Tryplasma radicula* (Rominger). (*1–2*), calyx and side views of lectotype from the Manistique dolomite, Point Detour, Mich. ×2; (*3–4*), calyx and side views of a paratype from the Hopkinton dolomite, Masonville, Iowa, ×2; (*5*), side view of unusually long and narrow specimen from Masonville, Iowa, showing repeated rejuvenation, ×2; (*6*), side view of short specimen from same locality, ×2; (*7*), transverse section of a hypotype from the Manistique dolomite, Raber, Michigan, ×2; (*8*) axial longitudinal section of another hypotype from the same horizon and locality, showing tabulae, ×2; (*9*), peripheral longitudinal section of another hypotype from the same horizon and locality, showing vertical rows of septal spines, ×4. (p. 842)

10–15—*Tryplasma brownsportensis* (Amsden). (*10–11*), calyx and side views of a typical specimen from the Louisville limestone at the "Falls of the Ohio" ×2; (*12*), longitudinal section of a large specimen from the same horizon and locality ×2; (*13*), transverse section of a specimen from the same horizon and locality ×2; (*14–15*), side views of long and short specimens showing limits of growth form ×2. (p. 842)

16–17—*Tryplasma gracilis* (Whiteaves). (*16*), view of polished surface showing ramose corallites ×1 (after Whiteaves); (*17*), view of interior of a single corallite ×6 (after Whiteaves). (p. 843)

18–19—*Tryplasma* sp. A. (*18–19*), calyx and side views of a specimen from the Keyser limestone, Cumberland, Maryland ×2. (p. 843)

Genus TRYPLASMA Lonsdale 1845

Tryplasma LONSDALE, 1845, p. 613.
Pholidophyllum LINDSTRÖM, 1870, p. 925.
Acanthodes DYBOWSKI, 1873, p. 364 (non *Acanthodes* Agassiz, 1833).
Spiniferina PENECKE, 1894, p. 592 (nom. nov. for *Acanthodes* Dybowski, 1873, p. 364).
Aphyllostylus WHITEAVES, 1904, p. 113.
Stortophyllum WEDEKIND, 1927, pp. 30–31.

Genotype.—By subsequent designation of Etheridge, 1907, p. 42, *Tryplasma aequibile* Lonsdale, 1845, pp. 613, 633, pl. A, figs. 7–7a. Silurian; River Kakva, east side of northern Ural Mountains, Russia.

Generic diagnosis.—Short or long, simple subcylindrical; or compound, loosely dendroid or phaceloid rugose corals with septa composed of vertical rows of spines. Tabulae complete, relatively horizontal, moderately to widely spaced. Dissepiments absent.

Remarks.—Species of the genus are characteristic of the Silurian strata of Europe and Australia. Four species are recognized from the Silurian of North America. Three of these were originally described as species of *Cyathophyllum* or *Amplexus;* the fourth was described as the monotypic species of a new genus.

TRYPLASMA RADICULA (Rominger)
Plate 125, figures 1–9

Cyathophyllum radiculum ROMINGER, 1876, p. 109, pl. 39, fig. 3 (partim).
Charactophyllum radiculum SIMPSON, 1900, p. 210.

Description.—Corallum simple, small, subcylindrical to ceratoid, with an invaginated exterior produced by closely repeated calycinal rejuvenescence. In most specimens lower part of corallum provided with one or more talons for purposes of attachment. Talons large, and irregularly shaped in some specimens, narrow and spinose in others. Epitheca thin, exposing well defined septal ridges. Calyxes with steeply inclined, almost vertical walls and wide, flat bases. Calyx walls with an average of 60 closely set acanthine septa with spines projecting axially from .5 to 1 mm. Major septa with slightly thicker and longer spines than those of the minor. No modifications of the protosepta visible in the calyx. Base of calyx composed of uppermost tabulum over which the septa do not extend.

In transverse section septal spines radially arranged, relatively thin, extending about one-third the distance to the axis.

In axial longitudinal section tabulae typically complete, relatively horizontal, spaced from 1 to 3 mm. apart, interspersed with occasional incomplete tabulae. Septal spines clearly defined along the periphery. Dissepiments absent. In longitudinal section near periphery acanthine septa well defined in vertical rows.

Remarks.—Simpson, 1900, p. 210, text-figure 29, assumed that the acanthine septa as seen in longitudinal section were carinae which caused him to assign this species to the genus *Charactophyllum*, a rugose coral genus with finely carinate lamellar septa. characteristic of the Upper Devonian.

Occurrence.—Middle Silurian (Manistique dolomite); northern Michigan. Middle Silurian (Hopkinton dolomite); vicinity of Masonville, Iowa.

Types.—Lectotype no. 8582a; paratypes nos. 8582b-d; hypotypes nos. 28523, 28524, and 28525, Museum of Paleontology, University of Michigan.

TRYPLASMA BROWNSPORTENSIS (Amsden)
Plate 125, figures 10–15

Cyathophyllum radiculum ROMINGER, 1876, p. 109 partim (specimens from the Louisville limestone only).
Cyathophyllum radiculum DAVIS, 1887, pl. 86, figs. 1–6.
Amplexus brownsportensis AMSDEN, 1949, pp. 106–107.

Description.—Corallum simple, small, subcylindrical to trochoid, usually with one or more talons of attachment near the base. Exterior with prominent annulations as in *T. radicula*. Calyx with acanthine septa extending about half way to the axis and with a central pit formed on the uppermost tabulum.

In transverse section, septa from 50 to 60, radially arranged, of two orders, the major extending from one-third to one-half the distance to the axis; the minor as short peripheral spines, not extending more than 1 mm. from the wall.

In longitudinal section tabulae typically concave, widely spaced. Acanthine septa clearly visible along periphery.

Remarks.—This species is distinguished from *T. radicula* by the longer major septa

and by the more widely spaced, concave tabulae

Occurrence.—Middle Silurian (Louisville limestone); Kentucky. Middle Silurian (Brownsport formation); western Tennessee.

Types.—Holotype no. 17666; paratypes nos. 17667, 17668, 17669, 17670, Yale Peabody Museum. Hypotypes nos. 5230, 28526, 28527, 28528, 28529, Museum of Paleontology, University of Michigan.

TRYPLASMA GRACILIS (Whiteaves)
Plate 125, figures 16, 17

Aphyllostylus gracilis WHITEAVES, 1904, p. 114; 1906, p. 279.

Description.—Corallum dendroid or phaceloid, consisting of cylindrical corallites ranging from 2 to 3 mm. in diameter. As seen on fractured surfaces, septal spines very short and slender; tabulae complete, typically horizontal, relatively widely spaced.

Remarks.—The only known specimens are imbedded in small blocks of limestone, and, therefore, their external features are unknown.

T. gracilis is the only known phaceloid species of the genus known from North America, although such forms are common in Silurian strata of Australia.

Occurrence.—Middle Silurian (Stonewall limestone); Stonewall, 31 miles west of East Selkirk, Manitoba, Canada.

Types.—Syntypes in the National Museum of Canada, Ottawa, Ontario.

TRYPLASMA sp. A
Plate 125, figures 18–19

Cyathophyllum radiculum SWARTZ, 1913, p. 202, pl. 19, figs. 12–17.

Description.—Corallum small, subcylindrical to ceratoid, typically with a large irregularly shaped talon of attachment at the base. Exterior relatively smooth, without prominent rejuvenation annulations and with prominent vertical interseptal ridges. Calyx with about 40 acanthine septa, radially arranged, extending from one third to one half the distance to the axis. Axial pit moderately deep, occupying central one third of calyx. Internal structures unknown.

Remarks.—This species differs from the other simple forms of *Tryplasma* in the possession of fewer septa and in the lack of prominent annulae. The preservation of the specimens makes it impossible to determine internal structures by thin section.

Occurrence.—Upper Silurian (Keyser limestone); Maryland, Virginia, and West Virginia.

Figured specimen.—No. 28530, Museum of Paleontology, University of Michigan.

MANUSCRIPT RECEIVED FEBRUARY 6, 1952

REFERENCES

AMSDEN, T. W., 1949, Stratigraphy and paleontology of the Brownsport formation (Silurian) of western Tennessee: Peabody Mus. Nat. Hist., Bull. 5.

BASSLER, R. S., 1937, The Paleozoic rugose coral family Paleocyclidae: Jour. Paleontology, vol. 11, pp. 189–201.

DAVIS, W. J., 1887, Kentucky fossil corals, pt. 2: Ky. Geol. Surv.

DYBOWSKI, W. N., 1873, Monographie der Zoantharia sclerodermata rugosa aus der Silurformation Estlands, Nord-Livlands und der Insel Gotland: Archiv. Naturk. Liv-, Ehst- und Kurlands, Bd. 5, Ser. 1, Lief. 4.

ETHERIDGE, R., 1907, A Monograph of the Silurian and Devonian Corals of New South Wales: Mem. Geol. Surv. New South Wales, Palaeont., vol. 13.

HILL, D., 1936, The British Silurian rugose corals with acanthine septa: Phil. Trans. Roy. Soc. London, ser. B, no. 534, vol. 226.

——, 1940, The Silurian Rugosa of the Yass-Bowning district, N.S.W.: Proc. Linn. Soc. New South Wales, vol. 65, pt. 3.

LONSDALE, W., 1845, Description of some Palaeozoic corals of Russia: in Murchison, de Verneuil, and von Keyserling, The geology of Russia in Europe and the Ural Mountains.

PENECKE, K. A., 1894, Das Grazer Devon: Jahrb. K.-K. Geol. Reichanst., Jahrg. 1893, Bd. 43.

ROMINGER, C., 1876, Paleontology. Fossil corals: Geol. Surv. Mich., vol. 3, pt. 2.

SWARTZ, C. K., 1913, Systematic Paleontology, Lower Devonian, Coelenterata: Maryland Geol. Surv., Lower Devonian.

WEDEKIND, R., 1927, Die Zoantharia Rugosa von Gotland . . . : Sver. geol. unders., ser. Ca, no. 19.

WHITEAVES, J. F., 1904, Description of a new genus and species of Rugose corals from the Silurian rocks of Manitoba: Ottawa Nat., vol. 18, pp. 113–114.

——, 1906, Palaeozoic fossils, vol. 3, pt. 4: Geol. Surv. Canada.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 844–846, 1 TEXT FIG., SEPTEMBER 1952

NOT *ASTRODAPSIS* IN JAPAN[1]

J. WYATT DURHAM
Museum of Paleontology, University of California, Berkeley

ABSTRACT—*Astrodapsis nipponicus*, described from Japan by Nisiyama in 1948, does not belong in that genus, and is made the type species of the new genus *Nipponaster*.

RECENTLY Nisiyama (1948) reported the occurrence of the characteristic Pacific Coast Miocene-Pliocene echinoid genus *Astrodapsis* in Japan, and at the same time noted that it had been recorded from the Neogene of Kamchatka and Sakhalin by Khomenko (1931) and Argamakova (1934). The record from Japan was based on a new species described by Nisiyama as *Astrodapsis nipponicus*, paratypes of which were distributed to several American institutions, including the Museum of Paleontology of the University of California at Berkeley.

During the preparation of the section on clypeastroid echinoids for the proposed TREATISE ON INVERTEBRATE PALEONTOLOGY considerable homeomorphy, at least with respect to surficial morphology, has been noted among the scutellid echinoids. Detection of this homeomorphy has been greatly facilitated by a systematic study of the arrangement of the plates on the oral surface of these echinoids. Fortunately the plate arrangements indicate the systematic relationships rather accurately while the ontogenetic changes shown in the successive plate arrangements of a growth series accurately reflects the phylogenetic relationships. Although no growth series of *Astrodapsis nipponicus* Nisiyama has been available to the present author, study of the plate arrangement on the oral surface of an adult paratype (text fig. 1-D) clearly indicates that this species is not closely related to *Astrodapsis antiselli* Conrad (text fig. 1-A), the type species of *Astrodapsis*, or to any of the other described species of this genus (a representative selection of which are shown in text fig. 1-B, C, E, F) from the Pacific Coast of the Americas. Accordingly this species is made the type of a new genus which is here described.

[1] A contribution from the Museum of Paleontology of the University of California.

Genus NIPPONASTER Durham, new genus

Type species: *Astrodapsis nipponicus* Nisiyama (1948) (Text fig. 1-D).

Small to moderate sized, more or less inflated, scutellid echinoids; oral surface moderately flattened, aboral surface arched, margin of ambitus rounded; outline somewhat elongated; petals elongate, wide open, length about three-fourths the radius of test; pore pairs conjugate; petals elevated, with intervening interambulacral depressions; four genital pores; apical system slightly anterior in position; peristome central, large, subpentagonal, with large interambulacral projections ("buccal tubes"?); periproct submarginal, large, situated at junction of sutures between second and third pairs of post-basicoronal interambulacral plates; ambulacral food grooves simple, unbranched; basicoronal plates of moderate size, interambulacral plates much larger than ambulacral plates; interambulacral areas on oral surface narrow, about one-fourth width of ambulacral areas; post-basicoronal interambulacral plates in contact with basicoronal plates in areas 1, 2, 3, and 4, moderately separated in area 5; on oral surface four to five post-basicoronal plates in interambulacral columns 1–4, three plates per column in area 5; about six or seven post-basicoronal plates in ambulacral areas on oral surface.

The narrow interambulacral areas on the oral surface, wide open petals, and the more distinctly submarginal periproct, readily separate *Nipponaster* from *Astrodapsis*. As

[2] All specimen numbers refer to the collections of the Museum of Paleontology of the University of California.

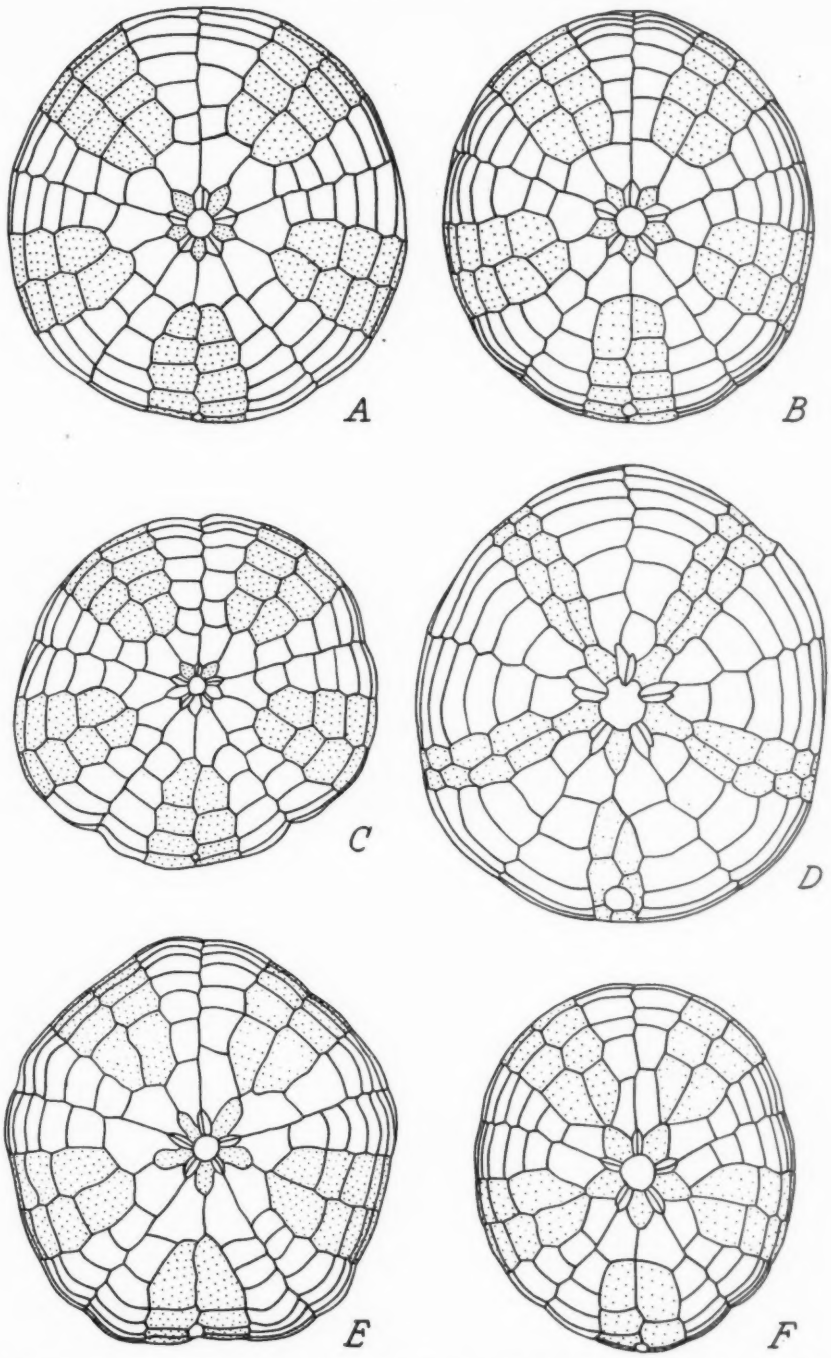


FIG. *1*—Arrangement of plates on oral surface in *Astrodapsis* and *Nipponaster*. A.—*Astrodapsis antiselli* Conrad ×0.93, after hypotype no.[2] 11030, the genotype of *Astrodapsis;* B.—*A. salinasensis* Richards ×1.05, hypotype no. 11373; C.—*A. grandis* Kew ×0.53, "cotype" no. 11046; D.—*A. nipponicus* Nisiyama ×2.5, paratype no. 30131, the genotype of *Nipponaster; A. gregersoni* Grant and Eaton ×1.05, paratype no. 34018; *A. brewerianus* (Rémond) ×1.8, neotype no. 11016.

may be seen from text figure 1, the interambulacral areas on the oral surface of typical *Astrodapsis* are much wider than in *A. nipponicus*. Furthermore this character is present in all known species from the Pacific Coast of North America. Although often not readily apparent until specimens are carefully prepared, studies on the scutellid echinoids on a worldwide basis have shown that the arrangement of the plates on the oral surface is highly significant in indicating relationships. Even though the general characters of *A. nipponicus* show considerable convergence with typical *Astrodapsis* from the Pacific Coast, evaluation of the plate arrangement does not indicate a particularly close relationship, other than that they both belong in the general *Echinarachnius* group of scutellid echinoids.

Although there is some variation in the various Pacific Coast species of *Astrodapsis* in the position of the periproct with relation to particular post-basicoronal plates, in the species where the periproct is submarginal, it is at the sutural junction between the third and fourth pairs of post-basicoronal plates (text fig. 1-B, 1-C). In *A. brewerianus*, (text fig. 1-F), the most primitive species currently referred to *Astrodapsis*, the periproct, when viewed from the oral surface, appears to be somewhat nearer the basicoronal region. However in this species the periproct is almost marginal in position and its comparative size is greater than the altitude of the plates on the ambitus. In actuality the midpoint of the periproct appears to occupy the same position as in the other species. The same effect is present in *A. gregersoni* (text fig. 1-E). In *A. nipponicus* the periproct is situated between the second and third pair of post-basicoronal plates and encroaches more strongly upon the second pair than the third, indicating that in this respect it is evolutionarily more advanced than the Pacific Coast species.

Comparison of the plates of the oral surface of *A. nipponicus* with the most primitive species of *Astrodapsis*, *A. brewerianus* (text fig. 1-F), in which interambulacral areas 1–4 are also in contact with the basicoronal plates also demonstrates the lack of affinity of the Japanese species with the genus *Astrodapsis*.

Khomenko (1931) and Argamakova (1934) have listed *Astrodapsis whitneyi* Rémond, *A. tumidus* Rémond, *A.* cf. *tumidus* Pack, and *A.* cf. *fernandoensis* Pack, from the Pliocene of Sakhalin, while Nisiyama (1948, p. 604) also cites Khomenko as reporting (in another paper in 1931) *A. pabloensis* Kew from the Miocene of Kamchatka. In the two papers seen (Khomenko, 1931 and Argamakova, 1934) the illustrations are extremely poor but in Khomenko's figure (pl. 1, fig. 2) of the oral surface of *Astrodapsis* cf. *fernandoensis* Pack, it can be seen that the interambulacral areas are narrow as in *A. nipponicus* and not wide as in *A. fernandoensis* from the Pacific Coast. It would appear that Khomenko's *A.* cf. *fernandoensis* is probably congeneric with *A. nipponicus*. Inasmuch as studies on the scutellids have shown a marked provincial distribution of undoubted members of the various genera (for instance studies of the genotype of *Scutella*, and of various species assigned to this genus from different parts of the world have shown that most of these species are improperly referred to it, and that the only species that can confidently be assigned to *Scutella* are European) and the only undoubted species of *Astrodapsis* are recorded from the Pacific Coast of North America south of 38° N. latitude, it appears highly probable that all of the remaining species recorded by Khomenko and Argamakova are incorrectly referred to *Astrodapsis*, and that they should probably be referred to *Nipponaster* or some other genus.

Astrodapsis nipponicus occurs in the "Mio-Pliocene" of Japan, while the species of *Astrodapsis* reported by Argamakova (1934) and Khomenko (1931) are listed as from the Pliocene. It appears therefore that the genus *Nipponaster* may have a similar range.

MANUSCRIPT RECEIVED JANUARY 4, 1952

REFERENCES

ARGAMAKOVA, V. F., 1934, On some Neogene Echinoidea of Sakhalin: Trans. Oil Geol. Inst. (Leningrad) (Leningrad. Neftianoĭ geologo-razvedochnyĭ institut. Trudy), Ser. A, fasc. 41, pp. 1–44, pls. 1–2.

KHOMENKO, J., 1931, Materials on the Stratigraphy of the Tertiary beds of the Eastern Sakhalin Oilfield: Trans. Geol. and Prospect. Serv. U.S.S.R. (Russia. Glavnoe geologo-razvedochnoe upravlenie. Trudy), Fasc. 79, pp. 1–126, pls. 1–12.

NISIYAMA, S., 1948, *Astrodapsis* in Japan: Jour. Paleontology, vol. 22, pp. 601–605, pl. 88.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 847–853, 3 TEXT FIGS., SEPTEMBER 1952

A CLASSIFICATION OF THE TRIASSIC AMMONOIDS

BERNHARD KUMMEL
University of Illinois

THIS is the third in a series of four papers on ammonoid classification by members of the ammonoid subcommittee for the forthcoming TREATISE ON INVERTEBRATE PALEONTOLOGY. A discussion of Jurassic ammonite classification with a phylogenetic chart has recently been published by W. J. Arkell (1950) and on Cretaceous ammonites by C. W. Wright (1952). A similar treatment on all Paleozoic ammonoids by A. K. Miller will appear shortly. It should be mentioned here that the relationships between Paleozoic and Triassic cephalopod families have been discussed on many occasions with Miller and we are in perfect agreement. Arkell (1950) has fully treated the nomenclatorial and taxonomic categories which are governing the preparation of the ammonoid chapter for the forthcoming Treatise and this material need not be repeated here.

Whereas no complete modern unified taxonomic scheme was available for Arkell with the Jurassic ammonoids or for Wright with the Cretaceous forms, the Triassic ammonoids have recently been fully covered by Spath (1934, 1951). This very thorough and masterly treatment of Triassic ammonoids represents a great advancement in this field of study. The over-all plan and arrangements of Triassic families in Spath's scheme goes far to express clearly the major lines of evolution and their probable relationships, and it is adopted here.

The writer was recently privileged to spend nearly seven months at the British Museum of Natural History studying the very large collections of Triassic ammonoids housed there. These are the collections upon which Spath based his two well-known British Museum Catalogues of Triassic ammonites. During this period the writer enjoyed numerous opportunities to discuss problems of cephalopod systematics and evolution with Dr. Spath. The long discussions with him and the inspiration which almost automatically results are gratefully acknowledged. The manuscript has been read by L. F. Spath, W. J. Arkell, C. W. Wright, A. K. Miller, R. C. Moore, and N. D. Newell. The writer is indebted for their helpful suggestions and comments.

The writer's studies have been a critical analysis of the various classificatory schemes of Triassic ammonites that have been proposed and an attempt to evaluate how well each one expresses the broader evolutionary pattern of these invertebrates. The classification which comes closest to the desired objectives is that by Spath, and it will therefore be used in the Treatise. Whereas the gross systematic arrangement followed here is that of Spath, the writer assumes responsibility for the phylogenetic arrangement of the families and superfamilies as presented in text figure 1. This chart is a diagrammatic interpretation of Triassic ammonoid phylogeny. The broader relationships of the superfamilies appear to be essentially correct; however, many of the families could have been placed in any of two or three possible positions with about equal propriety. The present arrangement is merely that which seems the most logical on the basis of present data. The organization and data presented by text figure 1 have been discussed on several occasions with Dr. Spath, and he is in general agreement with it.

There have been numerous previous attempts to classify Triassic ammonites; e.g. those of Haug (1894, 1898), Hyatt (1889, 1900), Hyatt and Smith (1905), Smith (1903, 1914, 1927, 1932), Arabu (1932), Arthaber (1911, 1914), and others. A brief review of these various schemes can be found in Spath (1934) and need not be discussed here. The classificatory system proposed by Spath differs particularly from most of the previous ones in the derivation of such Middle and Upper Triassic groups as the Ptychitaceae, Arcestaceae, Tropitaceae, etc. from Lower Triassic stocks. Most of the earlier authors derived these superfamilies from various members of the "*Gastrioceras*" branch of the Paleozoic am-

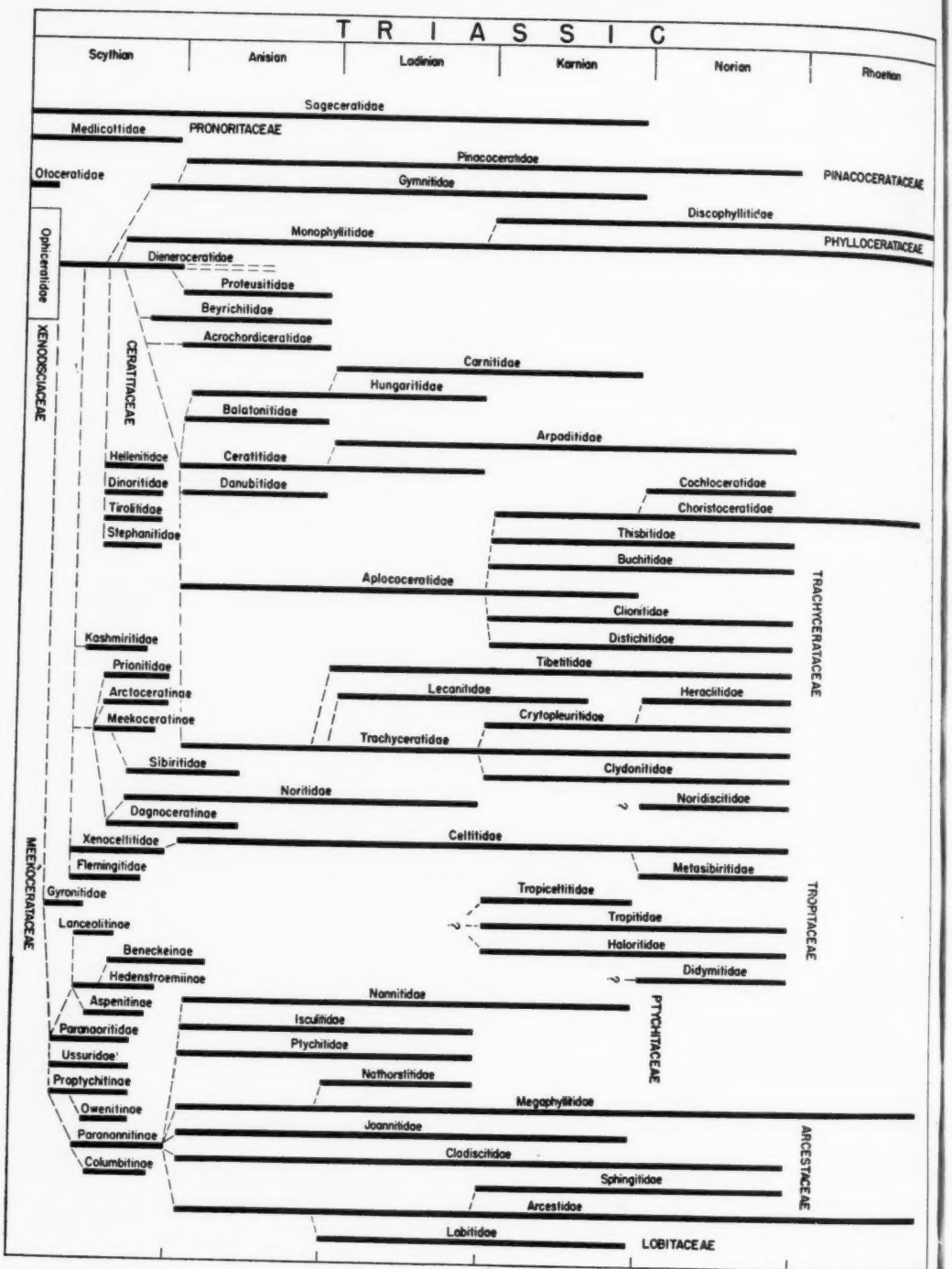


FIG. 1—Schematic diagram illustrating the supposed phylogeny of Triassic ammonoids. The reader is cautioned not to assume any finality in this chart or in those of figures 2 and 3.

monoid stocks in spite of the fact that no transitional forms are known from the Lower Triassic.

Students of Jurassic and Cretaceous ammonoids are generally agreed upon recognizing three suborders, namely the Phylloceratina, Lytoceratina, and Ammonitina. The concept for these three great subdivisions goes back to E. Suess (1865). No comparable taxonomic categories are in general use for Triassic ammonites. Likewise there is no working hypothesis as Salfeld's theory of Iterative Evolution of the post-Triassic ammonites. Triassic ammonites are less well known and appear to be a much more heterogeneous assemblage than their Jurassic and Cretaceous descendants.

The extinction of the ammonites during the Maestrichtian is well known. There was a period of near extinction in the Rhaetic, an excellent discussion of which can be found in Diener, 1920. Known Rhaetic ammonites are confined to merely five genera; *Arcestes*, *Megaphyllites*, *Choristoceras*, *Cladiscites*, and *Eopsiloceras*. *Choristoceras* is an aberrant Upper Triassic genus that began to uncoil. The other four genera are representatives of long-persisting stocks that made their appearance in the Anisian. The decline in Triassic ammonites is already noticeable in the upper Norian. The only stock which was destined to survive the close of the Triassic are the Phylloceratidae. The Monophyllitidae gave rise to the lytoceratids and psyloceratids, and the Discophyllitidae gave rise to the phylloceratids (Spath, 1934). Thus with the exception of the Phylloceratidae all the Triassic stocks became extinct near the end of the period.

In the classification adopted here, the Triassic ammonites are divided into 11 superfamilies all of which are of long standing. Their phylogenetic relationships are diagrammatically shown in text figure 2. The Pronoritaceae are primarily an Upper Paleozoic group. There is one genus of the Medlicottidae in the Lower Triassic. The Sageceratidae are a Triassic family ranging from the Scythian to the Karnian. Both of these groups are direct continuations of Paleozoic stocks. The Xenodisciaceae include both late Paleozoic and early Triassic families. The Otoceratidae include both Permian and Lower Triassic genera but do not appear to have given rise to any other Triassic developments. The most important early Triassic family is the Ophiceratidae. From this stock all the remaining Triassic families are directly or indirectly derived. The Ophiceratidae are confined to the earliest Scythian. This root stock, however, is continued through at least the middle and upper Scythian by the Dieneroceratidae.

The Meekocerataceae are a predominantly Scythian radiation stemming from the Ophiceratidae and the Dieneroceratidae of the Xenodisciaceae. They show some modification of the ventral region, development of globose, carinate, or ribbed offshoots, and some elaboration of the suture. From one of the globose developments of the Meekocerataceae are derived the Ptychitaceae and Arcestaceae. The Tropitaceae stem at least in part from the Meekocerataceae. The Lobitaceae are a Ladinian and Karnian group probably stemming from the Arcestaceae. The Pinacocerataceae, Phylloceratidae, and Ceratitaceae are radiations from the *Dieneroceras* root stock. The Trachyceratidae are descended from the Ceratitaceae and are derived at more than one time from various elements of the Ceratitaceae. Their separation from the Ceratitaceae at the present is a matter of expediency because of the large number of families involved. The Arpaditidae are typically with a median furrow bordered by a continuous smooth or crenulated keel. They are a polyphyletic group derived at different times from the ceratitids. The Trachyceratidae stem from the Ceratitidae early in the Anisian. The Clionitidae, Buchitidae, Distichitidae, Thisbitidae, and Choristoceratidae are typically evolute, ribbed Karnian-Norian stocks that are thought to stem from a ceratitid root in the Aplococeratidae of the Ceratitaceae. The Trachyceratidae are considered already too highly specialized to be ancestral to these families

This very generalized picture of the interrelationships of the Triassic ammonoid stocks shows a large and somewhat random radiation of the Xenodisciaceae, Meekocerataceae, and some Ceratitaceae in the Scythian. Most of the elements in this radiation were presumably unsuccessful for they

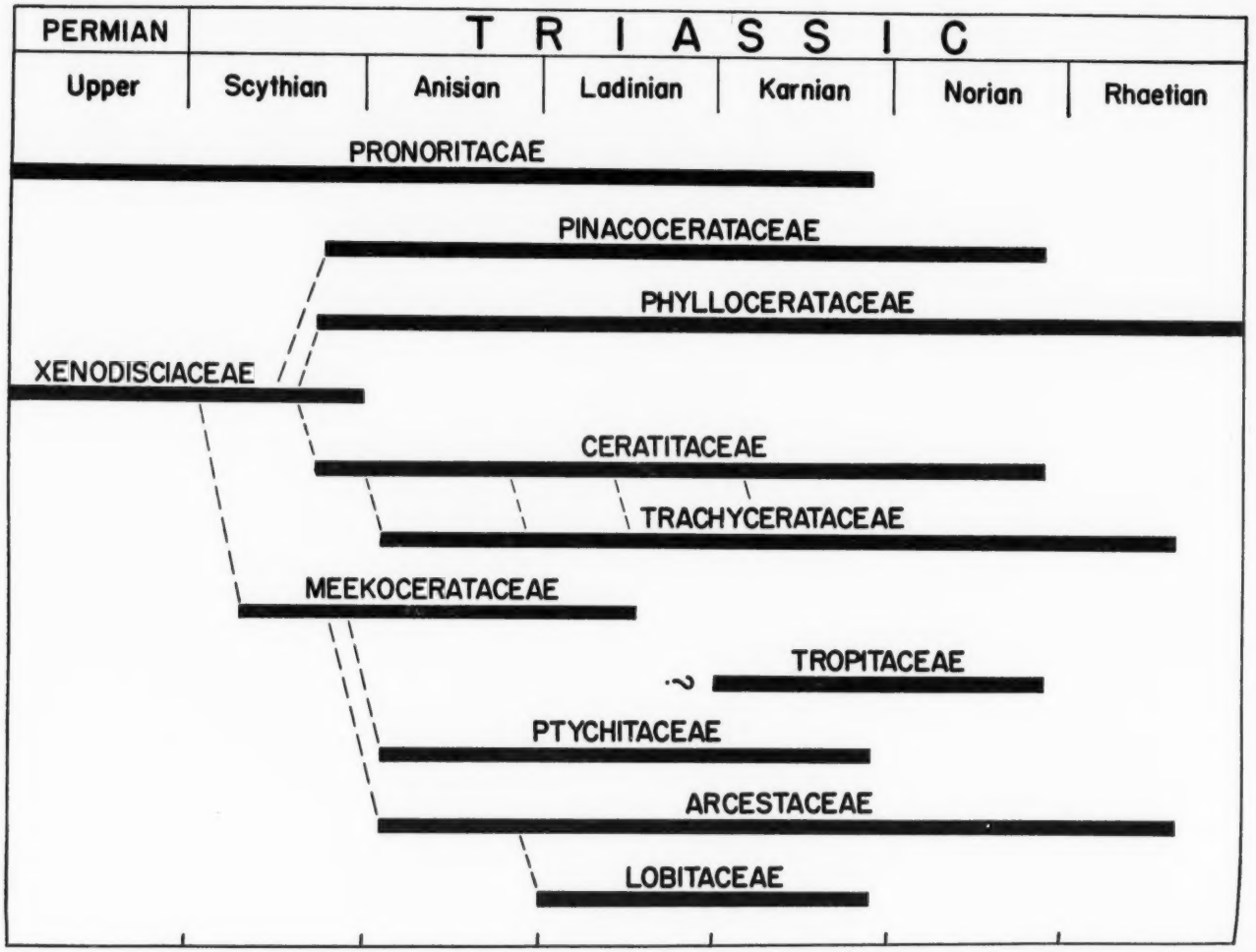


FIG. 2—Schematic diagram illustrating the phylogenetic relationships of Triassic ammonoid superfamilies.

were short lived. In the Anisian the Pinacoceratacеae, Phylloceratacеae, Ceratiaceae, Trachyceratacеae, Tropitaceae (in part), Ptychitaceae, and Arcestaceae arise and the major lines of development that continue until at least the Norian become established.

As mentioned above a similar paper on all Paleozoic ammonoids will be published shortly by A. K. Miller. The few brief general remarks made here on Paleozoic ammonoids are only for the purpose of clarifying the relationships of late Paleozoic and Triassic ammonite families and to establish a subordinal classification compatible with that for Jurassic and Cretaceous ammonites. There seem to be two main stocks of Carboniferous and Permian ammonoids (Spath, 1934, Miller and Furnish, 1940). Miller and Furnish (1940) place the Gastrioceratidae, Thalassoceratidae, Adrianitidae, Agathiceratidae, Popanoceratidae, Perrinitidae, and Cyclolobidae in one "group." In the other "group" they include the Prolecanitidae, Pronoritidae, Medlicottidae, Daraelitidae, Paraceltitidae, and Xenodiscidae. The early Triassic families Ophiceratidae and Otoceratidae are thought to stem from the Xenodiscidae (Spath, 1934). The Medlicottidae continue into the Scythian with only one genus, and the Sageceratidae are a Triassic development out of a medlicottid stock. The relationship of Permian and Triassic ammonites outlined above shows clearly that the Triassic ammonites are derived from only one of the "groups" of Paleozoic ammonoids. The other "group" became completely extinct by the close of the Permian. Since there is a broad trend and pattern in the evolution of the prolecanitid "group" that in a sense blends evenly into those Lower Triassic stocks from which a new and greater radiation took place, it is proposed to place all the Paleozoic ammonoids of the prolecanitid "group" and their Triassic descendants into one suborder—the Ceratitina. The other "group" of Paleozoic ammonoids which did not give rise to any Triassic forms is named the Goniatitina. Under this plan the

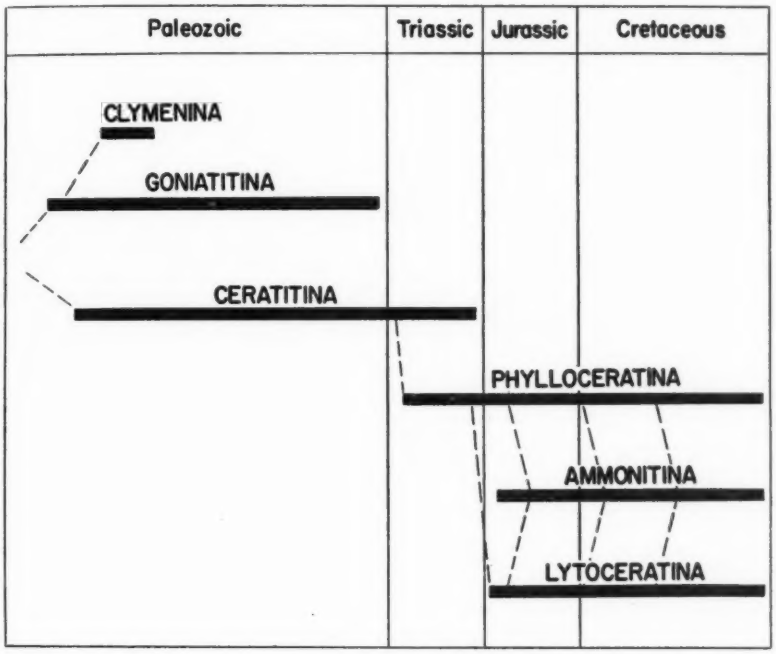


FIG. 3—Schematic diagram illustrating the phylogenetic relationships of the suborders of the Ammonoidea.

FIG. 2—Schematic diagram illustrating the phylogenetic relationships of Triassic ammonoid superfamilies.

broader relationships of the Ammonoidea are expressed simply in six suborders, the Goniatitina, the Clymenina, the Ceratitina, the Phylloceratina, the Lytoceratina, and the Ammonitina (text figure 3).[1]

THE PROPOSED CLASSIFICATION

Order AMMONOIDEA

Suborder Ceratitina Hyatt 1889

Superfamily Pronoritaceae Hyatt and Smith 1905
- Family Medlicottidae Karpinsky 1889
- Family Sageceratidae Hyatt 1900

Superfamily Xenodisciaceae Frech 1902
- Family Otoceratidae Hyatt 1900
- Family Ophiceratidae Arthaber 1911
- Family Dieneroceratidae[2] nov.

Superfamily Meekocerataceae Waagen 1895
- Family Gyronitidae Waagen 1895
  - Subfamily Gyronitinae Waagen 1895
  - Subfamily Kymatitinae Waagen 1895
- Family Flemingitidae Hyatt 1900
- Family Xenoceltitidae Spath 1930
  - Subfamily Xenoceltitinae Spath 1934
  - Subfamily Inyoitinae Spath 1934
- Family Paranoritidae Spath 1930
- Family Proptychitidae Waagen 1895
  - Subfamily Proptychitinae Waagen 1895
  - Subfamily Owenitinae[3] Spath 1934
- Family Paranannitidae Spath 1930
  - Subfamily Paranannitinae Spath 1934
  - Subfamily Columbitinae Spath 1934
- Family Ussuridae Spath 1930
- Family Hedenstroemiidae Waagen 1895
  - Subfamily Hedenstroemiinae Spath 1934
  - Subfamily Lanceolitinae Spath 1934
  - Subfamily Aspenitinae Spath 1934
  - Subfamily Beneckeinae[4] Waagen 1895
- Family Kashmiritidae Spath 1934
- Family Meekoceratidae Waagen 1895
  - Subfamily Meekoceratinae Waagen 1895
  - Subfamily Arctoceratinae Arthaber 1911
  - Subfamily Dagnoceratinae Spath 1934
- Family Nortidae Karpinsky 1889
- Family Prionitidae[5] Hyatt 1900
- Family Sibiritidae[5] Mojsisovics 1896

Superfamily Ceratitaceae Hyatt 1900
- Family Stephanitidae Arthaber 1896
- Family Tirolitidae Mojsisovics 1882
- Family Dinaritidae Mojsisovics 1882
- Family Hellenitidae[6] nov.
- Family Acrochordiceratidae Arthaber 1911
- Family Beyrichitidae Spath 1934
- Family Ceratitidae Mojsisovics 1879
- Family Danubitidae[7] Spath 1951
- Family Balatonitidae Spath 1951
- Family Hungaritidae Waagen 1895
  - Subfamily Hungaritinae Arthaber 1911
  - Subfamily Longobarditinae Spath 1951
- Family Carnitidae Arthaber 1911
- Family Proteusitidae Spath 1951
- Family Aplococeratidae Spath 1951

Superfamily Trachyceratataceae Haug 1894
- Family Trachyceratidae Haug 1894
- Family Clydonitidae Mojsisovics 1879
- Family Clionitidae Arabu 1932
- Family Arpaditidae Hyatt 1900
- Family Lecanitidae Hyatt 1900
- Family Heraclitidae Diener 1920
- Family Cyrtopleuritidae Diener 1925
- Family Tibetitidae Hyatt 1900
- Family Buchitidae Hyatt 1900
- Family Thisbitidae Spath 1951
- Family Noridiscitidae Spath 1951
- Family Distichitidae Diener 1920

[1] The establishment and scope of these suborders has been worked out with A. K. Miller. The Clymenina are included here only for the sake of completeness and will be discussed thoroughly by Miller.

[2] Dieneroceratidae nov. for *Dieneroceras* Spath, 1934, including the persisting Scythian root stock elements from the Ophiceratidae.

[3] Schindewolf (1941, Jahrb. Reichsstelle Bodenforschung für 1939) proposed a separate superfamily (Owentida) for this group on the basis of the non-ventral position of the siphuncle; for a general statement on siphuncular structures of Triassic ammonites see Spath 1950, and Voorthuysen, 1940.

[4] The systematic position of this subfamily is very uncertain.

[5] Spath included these two families in the Ceratitaceae. They are here placed in the Meekoceratataceae because phylogenetically they appear to be derived from the Meekoceratidae, whereas all the families of the Ceratitaceae are derived from either the persisting *Ophiceras* root stock (e.g. Dieneroceratidae) or the Ceratitidae.

[6] Hellenitidae nov. for *Hellenites* Renz and Renz, 1948: *Pseudarniotites* Spath, 1951, appears to be a subjective synonym of *Hellenites*.

[7] *Rikuzenites* Yabe, 1949 (Proc. Japan Acad., vol. 25) an Anisian ammonoid with a conch coiled as in typical Cretaceous *Scaphites* is tentatively placed in the Danubitidae. When and if this genus becomes better known it should probably be placed in a separate family.

Family Choristoceratidae Hyatt 1900
Family Cochloceratidae Hyatt 1900
Superfamily Tropitaceae Hyatt 1900
Family Tropitidae Mojsisovics 1893
Family Tropiceltitidae Spath 1951
Family Celtitidae Mojsisovics 1893
Family Metasibiritidae Spath 1951
Family Haloritidae Haug 1894
Subfamily Haloritinae Spath 1951
Subfamily Sagenitinae Spath 1951
Subfamily Episculitinae Spath 1951
Family Didymitidae Haug 1894
Superfamily Lobitaceae Hyatt 1900
Family Lobitidae Mojsisovics 1893
Superfamily Arcestaceae Hyatt 1900
Family Arcestidae Mojsisovics 1875
Family Joannitidae Mojsisovics 1882
Family Sphingitidae Arthaber 1911
Family Cladiscitidae Zittel 1884
Family Megaphyllitidae Mojsisovics 1896
Family Nathorstitidae Spath 1951
Superfamily Ptychitaceae Mojsisovics 1882
Family Ptychitidae Mojsisovics 1882
Family Isculitidae Spath 1951
Family Nannitidae Mojsisovics 1897
*Superfamily Pinacoceratacea*e Mojsisovics 1896
Family Pinacoceratidae Mojsisovics 1896
Family Gymnitidae Waagen 1895
Suborder Phylloceratina Arkell 1950
*Superfamily Phylloceratacea*e Hyatt 1900
Family Monophyllitidae Smith 1913
Family Discophyllitidae Spath 1927

REFERENCES

ARABU, N., 1932, Essai d'une nouvelle classification des Ammonidés triasiques; vue générale de leurs origines: Bull. Soc. géol. France, 5th ser., tome 2, pp. 237–274.

ARKELL, W. J., 1949, Jurassic ammonites in 1949: Science Progress, no. 147, pp. 401–417, pl. 1.

——, 1950, A classification of the Jurassic Ammonites: Jour. Paleontology, vol. 24, pp. 354–364.

ARTHABER, G. VON, 1911, Die Trias von Albanien: Beitr. Paläontologie Oesterr.-Ungarns des Orients, Bd. 24, pp. 169–277, pls. 17–24.

——, 1914, Die Trias von Bithynien (Anatolien): Beitr. Paläontologie Oesterr.-Ungarns u. des Orients, Bd. 27, pp. 85–206, pls. 11–18.

DIENER, C., 1920, A critical phase in the history of ammonites: Am. Jour. Sci., 5th ser., vol. 4, pp. 120–126.

HAUG, E., 1894, Les Ammonites du Permien et du Trias: Bull. Soc. géol. France, 3rd ser., tome 22, pp. 385–412.

——, 1898, Études sur les Goniatites: Soc. géol. France Mém., Paléont., tome 7, no. 18, pp. 1–112, pl. 20.

HYATT, A., 1889, Genesis of the Arietidae: Smithsonian Contributions to Knowledge, no. 673, pp. 1–238, pls. 1–13, Washington.

——, 1900, Cephalopods: Zittel-Eastman Textbook of Paleontology, vol. 1, pp. 502–604.

——, and SMITH, J. P., 1905, The Triassic cephalopod genera of America: U. S. Geol. Survey Prof. Paper 40, 394 pp., 85 pls.

MILLER, A. K., and FURNISH, W. M., 1940, Permian Ammonoids of the Guadalupe Mountain region and adjacent areas: Geol. Soc. America, Spec. Paper no. 26, 242 pp., 44 pls.

SMITH, J. P., 1903, The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, pp. 1–211, pls. 1–29.

——, 1914, The Middle Triassic invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 83, pp. 1–254, pls. 1–99.

——, 1927, Upper Triassic marine invertebrate faunas of North America: U. S. Geol. Survey Prof. Paper 141, pp. 1–262, pls. 1–121.

——, 1932, Lower Triassic ammonoids of North America: U. S. Geol. Survey Prof. Paper 167 pp. 1–199, pls. 1–81.

SPATH, L. F., 1934, 1951, Catalogue of the fossil cephalopods in the British Museum (Natural History), Part 4, The Ammonoidea of the Trias, (I), pp. 1–521, pls. 1–18 (1934); (II), pp. 1–228 (1951) London.

SUESS, E., 1865, Über Ammoniten: Sitzungsber. Akad. Wiss. Wien, Bd. 52 (1866), pp. 71–89.

WRIGHT, C. W., 1952, A classification of the Cretaceous ammonites: Jour. Paleontology, vol. 26, pp. 213–222.

MANUSCRIPT RECEIVED MAY 26, 1952

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 854–858, 4 TEXT FIGS., SEPTEMBER 1952

PALEONTOLOGICAL NOTES

A NOTE ON ROSS' "ONTOGENIES OF THREE GARDEN CITY (EARLY ORDOVICIAN) TRILOBITES"

FRANK RAW
Birmingham University, England

ABSTRACT—The three pairs of spines of larval heads of the olenid *Leptoplastus*, which Raw deduced to characterize the heptacicephalic ancestor of the trilobite (1925 and 1927), are claimed to be represented in the ontogenies of relatives of olenids described by Ross. These spines are claimed also as special pleural spines "macrosomites" of the proarthropod ancestor. But in the larval heads of a proparian and less primitive trilobite described by Ross only the posterior pair are found, other spines present being adventitious and comparable in origin with such as are abundantly present in later trilobites.

INTRODUCTION

In 1925 and 1927 Raw defined the three pairs of peripheral head spines in the early Ordovician olenid, *Leptoplastus salteri*, by their relation to the anterior and posterior branches of the facial sutures, and named them: 1, Procranidial, at the anterior corners of the cranidium, in front of the anterior branches of the sutures; 2, Parial, on the free cheeks (the genal spine in such mesoparial trilobites); and 3, Metacranidial, at the posterior corners of the cranidium behind the posterior branches of the sutures. These spines and the parts of the facial suture associated with them were claimed as morphological entities and were identified in other trilobite families (Raw, 1925, p. 232).

In *Leptoplastus* only meraspid stages are certainly known, and the exposure of the spines was due to the complete removal of the flattened calcareous tests by solution, which caused the shale to split at the levels of abundant fossils.

In a forthcoming paper it is claimed that these pairs of spines are pleural spines of head segments, the procranidial being that of the first dorsal head segment; the parial, that of the third coalesced with that of the fourth; the metacranidial, that of the 6th dorsal, the last or occipital segment.

Except in the Olenellidae where procranidial spines, by themselves (1925, pp. 303–307; 1937, p. 577), or coalesced with the parial form the genal spines (Raw, 1936, pp. 241, 263; 1937, p. 577), this particular pair have not been recognized in the ontogeny of other trilobites. But now in 1951, Ross reveals the occurrence of just the same features in early Ordovician species; but he does not rightly identify them. It is the first two of his ontogenetic series of these trilobites, with which we are concerned (Ross, 1951 B, pp. 579–582, pls. 81–83). In both cases very early stages, from minute protaspids, are available; and, being silicified, they can be completely isolated from the matrix and studied from every direction.

ONTOGENY OF *Menoparia* AND/OR *Scinocephalus*

The first series is that of the two *Apatocephalus*-like genera *Menoparia* and/or *Scinocephalus*, both of them established by Ross; for, when the cephalon is less than 0.85 mm. long, these genera cannot be distinguished from one another. These genera are relatives of the Olenidae, as indicated by the head shield and by its median anterior ventral suture; but they are more primitive by their long eyes. They are related both to Dicellocephalidae and Remopleuridae. Both protaspids by their very extensive enrolment support the claim that very many figured protaspids are incompletely exposed.

Throughout protaspid development the peripheral spines are exhibited, but only in the larger where the axial lobe is better defined, are the trilobite features fully indicated. Ross makes the important discovery that the free cheeks are missing, the

specimens being bounded, where these occur, by facial sutures, which extended round the long eye lobes.

He represents an "anaprotaspid" in different attitudes (pl. 81, figs. 1–3), and a "metaprotaspid" in successive stages of rotation round a transverse axis (figs. 4–9) together with early cranidia (figs. 10–14). All are ×30. All the figures 1–13 exhibit procranidial spines having exactly the same relation to the cranidium and the suture as the procranidials in *Leptoplastus salteri*. These are the longest spines, directed upward in figures 1–6, 12 and 13; and downward and lowest in figures 8 and 9. Of the identity of these there can be no doubt whatever, though Ross does not so identify them.

Besides these there are at least two other pairs. The more conspicuous of these diverge from near the posterior end of the body in both protaspids: they are seen in figures 1–3 to right below, in 4 to left below, in 8 above the procranidials and directed towards them, and in 9 in the middle on each side. Ross regards these as belonging to the protopygidium; but they are claimed here as metacranidial spines. Both these and the procranidial are peripheral pairs: the 3rd peripheral pair, the parial, would also certainly be present, borne on the free cheek, as is seen in the meraspid half head (figs. 10 and 11). An additional subordinate pair of spines appears in figure 5 bottom left, and in figures 6 and 7 bottom right and left; but these are not peripheral, as they occur on the cranidium where it is bordered by the free cheek. They are adventitious (see below).

If as is here claimed the posterior pair of spines are the metacranidial, they belong to the occipital segment; whereas according to Ross they belong to the protopygidium. His argument is (l.c., p. 580), that in the "metaprotaspid" at the zone of sharpest flexure (his figs. 6–7) the axis is crossed by two furrows defining a ring, in front of which the glabella is not segmented. This suggests to him comparison with the early meraspid stages (figs. 10–13) where the occipital is the only defined ring; and he concludes therefore that the posterior spines are behind the occipital segment. This ring is seen in his figure 6 below the center, in figure 7 a little above, and in figure 8 nearly at the top and with two rings below it, the bottom one of which may well be the segment carrying the spines as pleural spines.

But three considerations support the writer.—

1. Plate 81, figure 5 presents the anterior part of a "cranidium," and is bounded at the sides behind the procranidial spines by the parallel anterior branches of the facial sutures, and then by the out-bowing palpebral lobes. Likewise figure 8 shows the posterior part of the same "cranidium," and is bounded at the sides by the out-bowing palpebral lobes followed by the posterior branches of the facial sutures in front of the metacranidial spines. The ring which Ross claims as the occipital is opposite the palpebral lobes. The writer claims it as the fourth dorsal segment of the six.

2. Considering how clearly segmented are the axial lobes in early stages of primitive trilobites, it may surprise us that the front of the glabella is not segmented. But as can be seen in the adult the glabella is in these species highly modified. In *Menoparia* there are in the adult only two very oblique furrows in front of the occipital (1951 A, pl. 20 and p. 88; 1951 B, pl. 83, fig. 20): in *Scinocephalus* only one very oblique pair shows itself conspicuously in the adult (1951 A, pl. 20, figs. 26 and 32). In both species they change greatly with age; but we can expect the glabella furrows to be represented by plain transverse furrows in the protaspis, just as is the case in *Leptoplastus*.

3. These forms are related to, but are much more specialized than *Dicellocephalus*, in which again only the two posterior glabella furrows characterize the adult. The lack of the two further furrows which are present in the most primitive trilobites, is attributable to changes consequent on the reduction of the appendages under cover of the hypostome and doublure.

These silicified protaspids exhibit remarkable peculiarities. In *Width* they are normal, e.g. the width across the front in the line of the bases of the procranidial spines is 0.5 mm. in the "anaprotaspis," 0.6 mm. in the "metaprotaspis," and 0.66 and 0.7 mm. in meraspid cranidia. But in *Form* there is a great contrast—the meraspid cranidia are fairly flat whereas the protaspids, which are practically their morphological equivalent, are as seen in figures 3 and 4 strongly coiled.

Also the *Proportion* of length to width is very different between say the metaprotaspis and the early meraspid stage: the protaspid is relatively considerably longer. It may be suggested that the exoskeleton of the protaspid, unlike that of the meraspid and adult, was purely organic in composition; and that after being sloughed it expanded in length and curled up, and in this altered form was embedded and silicified. It is improbable that the curvature was imposed by close adaptation to the spherical egg, as might be suggested by *Limulus*.

It is therefore claimed that, thanks to silicification and the technique of isolating them, these protaspids exhibit both procranidial and metacranidial spines well developed.

Later, in the earliest meraspid stage, in which the free cheek with its parial spine is found, the metacranidial spine seems to be represented by its last vestige (l.c., pl. 81, figs. 10 and 11) a little within the parial spine. But very soon after this the large procranidial as well as the small metacranidial disappear leaving only the parial of the adult.

ONTOGENY OF *Pseudocybele nasuta* ROSS

In the other ontogeny described, that of the proparian *Pseudocybele nasuta* Ross, he is dealing with a much less primitive trilobite, and only the genal spine which is here the metacranidial corresponds to a peripheral spine of *Leptoplastus*. But in front of this are two or three adventitious spines, such as characterize some other cheirurids as well as odontopleurids. Ross however makes the mistake of calling the anterior and largest one a "procranidial" spine, though he agrees that it is not so. This indeed it cannot be, if, as Raw claims, the facial suture is a morphological entity; for though it is situated anteriorly, it lies behind the posterior branch of the facial suture, and therefore on our theory upon the occipital segment. In the cheeks of the head this proparian is highly specialized, for the pleura of its occipital segment are enormously enlarged and on their periphery or near it they bear the adventitious spines.

In one respect these two very different ontogenies agree: they both support the present writer in his contention that the dorsal axial lobe of the cephalon represents six segments, for the anterior lobe of the glabella in *Pseudocybele* is in early stages twice as long as the succeeding ones, as is the case in *Leptoplastus*, and in the earlier described genera the axial lobe has a corresponding length.

In an earlier memoir, Ross described the ontogeny of another proparian, *Protopliomerops superciliosa* Ross, which in its anterior margin and in its eye-lobe is less specialized than *Pseudocybele* (1951 A, pp. 145–150; fig. 4, p. 147, pls. 31, 32). He describes its earliest stage, at a length of 0.27 mm. as "already trilobed" and bearing "three *main* pairs of spines," which he traces through a series of stages. The statement suggests to the writer that the number of spines is indefinite, and that as in *Pseudocybele* all but the posterior and largest are adventitious. The posterior on the contrary persists as the genal spine of the adult, and is accepted as the metacranidial (p. 148). In this species he saw no evidence that the free cheek was missing as was the case in *Pseudocybele*.

But in his discussion he quite misinterprets the present writer, and makes the following erroneous statements (l.c., p. 148)—"In 1925 Raw advanced the theory" . . . "that the *basic trilobite protaspis* possessed three pairs of lateral spines" . . . "The first of these" (the procranidial spine) "according to Raw is located in front of and *inside the eyes;* and in this particular we find his theory inapplicable to *Protopliomerops*, in which the so-called "procranidial spine" is located outside the eye, and occupies the position assigned by Raw to the *parial spine in proparian trilobites* (1925, pl. 15, figs. 1, 3 and p. 319)." It is however unnecessary to enlarge on the italicized mistakes. Both procranidial and parial are lost, as is characteristic of proparian trilobites, and apart from the metacranidial only adventitious spines occur, a kind quite absent from the more primitive trilobites. The photographs of his plate 32, ×8, are inadequate, in contrast with those of his later paper, and the ontogeny of *Protopliomerops* will, one hopes, receive further treatment. In the same memoir his plates 8–13 illustrate

how readily adventitious spines arise by development of pustules.

A great future has opened with the study of these silicified tests. The silicification is to be explained by the less stable composition of the trilobite skeletons as compared with the limestone matrix; and suggests that they were mainly aragonite in contrast with the calcite of the latter. Seeing that the replacement is not universal in limestones containing chert it must be attributed to exceptional conditions, and it may well have been hypogenic heat that in this case mobilized the silica, and effected replacement or deposition. In the Garden City formation the silicification of the trilobites may have coincided with that which produced the quartzites in the overlying Swan Peak formation. In Britain it appears probable that the silicification of the Cambrian and Ordovician quartzites is related to Ordovician volcanism. In the United States a less severe hypogenic action effected it. Ross indicates how great was the amount of colloidal silica available and gives evidence for the emplacement of some of it after the jointing of the rocks. Supporting the theory of the aragonite composition of trilobite tests is the fact that where not silicified they are of rather coarsely crystalline calcite without any organic arrangement of the crystal grains. In this case the course of geological time at least since the Paleozoic has effected recrystallization into the more stable calcite; whereas in silicified tests the original opal has changed into quartz.

REFERENCES

RAW, F., 1925, The development of *Leptoplastus salteri* and of other trilobites (Olenidae, Ptychparidae, Conocoryphidae, Paradoxidae, Phacopidae and Mesonacidae): Quart. Jour. Geol. Soc. London, vol. 81, pp. 223–324.

——, 1927, The ontogenies of trilobites and their significance: Am. Jour. Sci., ser. 5, vol. 14, pp. 7, 131, 240.

——, 1936, Mesonacidae of Comley in Shropshire with a discussion of classification within the family: Quart. Jour. Geol. Soc. London, vol. 92, pp. 236–293.

——, 1937, The systematic position of the Olenellidae (Mesonacidae): Jour. Paleontology, vol. 11, pp. 575–597.

ROSS, R. J., JR., 1951 A, Stratigraphy of the Garden City formation in northeastern Utah and its trilobite faunas: Peabody Mus. Nat. Hist., Yale, Bull. 6.

——, 1951 B, Ontogenies of three Garden City (early Ordovician) trilobites: Jour. Paleontology, vol. 25, pp. 578–586, pls. 81–83.

AN EXAMPLE OF HOMEOMORPHY FROM A JURASSIC AMMONITE FAUNA

OTTO HAAS

The American Museum of Natural History, New York

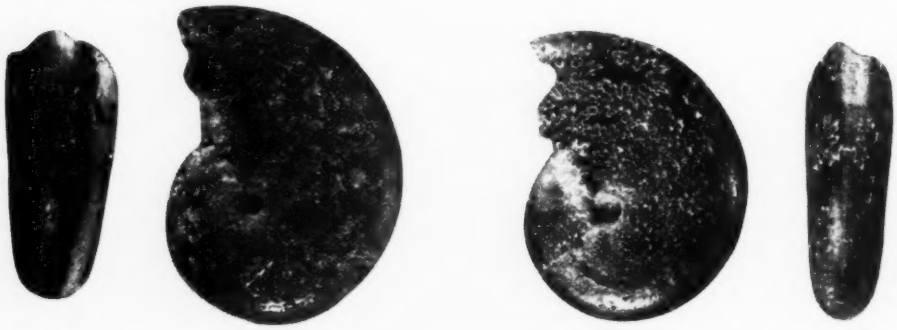
Revision of the Ammonoidea from Majdal Shams, Mt. Hermon, Syria, yielded the following remarkable illustration of homeomorphy.

Of some small ammonites nearly[1] indistinguishable in side and ventral views the ones, exemplified by the specimen illustrated in figures 1 and 2, can be identified by their suture lines as juveniles of the genus *Calliphylloceras*, probably belonging to *C. schems* (Noetling, 1887, p. 13, pl. 2, fig. 1; Frebold, 1928, p. 192), the others, exemplified by the specimen illustrated in figures 3 and 4, as individuals of *Taramelliceras* (*Proscaphites*) *richei* (de Loriol, 1898, p. 52, pl. 4, figs. 13–16; 1900, p. 46, pl. 3, fig. 26; Arkell, 1939, p. 147, cum synon., pl. 8, figs. 1–4).

Comparison of figures 1 and 4 clearly shows that the siphonal lobe is narrow and divided by a high and slender, arrow point-shaped median knob in *Calliphylloceras* sp., but that it is much wider and divided by a comparatively low, trapezoidal median knob

[1] Regardless of suture lines, the following differences are recognizable when the side views, figures 2 and 3, are compared: The umbilicus is somewhat narrower, and the whorl height increases faster, in *Calliphylloceras* sp. (fig. 2) than in *Taramelliceras* (*Proscaphites*) *richei* (fig. 3). Furthermore, an indication of a constriction can be recognized just in front of the last suture line in *Calliphylloceras* sp. (fig. 2). However, these differences, except the last, do not go beyond the degree of individual differences occurring within a species.

with three tiny horns, one each in the middle and at the two corners, in *Taramelliceras richei*. Also the terminal leaves of the adjacent branches of the external saddles can clearly be recognized to be phylloid in the former species but not in the latter.



1 2 3 4

FIGS. *1, 2*—*Calliphylloceras* sp., probably *Calliphylloceras schems* (Noetling). (In fig. *1* the specimen is slightly inclined to the right.)
3, 4—*Taramelliceras* (*Proscaphites*) *richei* (de Loriol). Both specimens from the Oxfordian of Majdal Shams, Mt. Hermon, Syria.
All figures enlarged ×3.
A.M.N.H. photographs taken by G. Robert Adlington.

The same difference—and others which need not be specified here—can be noticed also in those portions of the suture lines which are visible in the side views (figs. 2 and 3) of these two forms. These sutural characteristics do not leave any doubt but that the form on the left is a phylloceratid, the one on the right an oppelid. According to Arkell's (1950) classification the two forms belong to different superfamilies (the one to the Phylloceratacеae, the other to the Oppeliaceae) and even to different suborders (Phylloceratina and Ammonitina, respectively).

Thus, this is a fine illustration of homeomorphy in Ammonoidea which can, however, in this case as in others, readily be unveiled by the study of sutural characters (Haas and Simpson, 1946, p. 339).

MANUSCRIPT RECEIVED FEBRUARY 8, 1952

REFERENCES

ARKELL, WILLIAM JOSCELYN, 1939, The ammonite succession at the Woodham Brick Company's pit, Akeman Street Station, Buckinghamshire, and its bearing on the classification of the Oxford Clay: Quart. Jour. Geol Soc. London, vol. 95, pp. 135–220, pls. 8–11.

——, 1950, A classification of the Jurassic ammonites: Jour. Paleontology, vol. 24, pp. 354–364, 2 figs.

FREBOLD, HANS, 1928, Die stratigraphische Stellung der Grenzschichten des syrischen Callovien und Oxford: Centralbl. f. Min. etc., Jg. 1928, Abt. B, pp. 183–201, 1 map.

HAAS, OTTO and GEORGE GAYLORD SIMPSON, 1946, Analysis of some phylogenetic terms, with attempts at redefinition: Proc. Amer. Philos. Soc., vol. 90, pp. 319–349.

LORIOL, P. DE, 1898, Étude sur les mollusques et brachiopodes de l'Oxfordien inférieur ou zone à *Ammonites renggeri* du Jura Bernois, etc., pt. 1: Mém. Soc. Pal. Suisse, vol. 25, 115 pp. 7 pls., 29 text figs.

——, 1900, Étude sur les mollusques et brachiopodes de l'Oxfordien inférieur ou zone à *Ammonites renggeri* du Jura Lédonien, etc.: ibid., vol. 27, 196 pp., 6 pls., 19 text figs.

NOETLING, FRITZ, 1887, Der Jura am Hermon. Eine geognostische Monographie. Stuttgart (Schweizerbart), V+46 pp., 7 pls.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, PP. 859–861, SEPTEMBER 1952

NOMENCLATURAL NOTES

NOTES ON THE TAXONOMY OF KINGSTONID TRILOBITES

PAUL TASCH
State University of Iowa

Some unpublished notes on the taxonomy of kingstonid trilobites have a bearing on the recent discussion of the subfamily Kingstoniinae and the genus *Kingstonia* (Shaw, Jour. Paleontology, 1952, vol. 26, pp. 471–472). Since both these notes and my material on Warrior kingstonids (Jour. Paleontology, 1951, vol. 25, pp. 275–306) contain certain information not incorporated in the recent paper, they are briefly discussed below.

The first item concerns suppression of the genus *Ithycephalus* on the basis that exfoliated specimens are found to be identical with similar specimens of *Kingstonia* (*Kingstonia*). In Warrior bed 12.61, minute cranidia of *Ithycephalus* occurred together with very much larger *Kingstonia ara* molt fragments. This suggests that the Warrior ithycephalids represented a very young molt stage of a kingstonid. Following Shaw's subgeneric designations, this would be *K. apion*. However, since they occur with *K. ara*, they may represent very young molts of that species.

The second item concerns erection of two subgenera, *Kingstonia* (*Kingstonia*) and *Kingstonia* (*Ucebia*). The types of the subgenera are respectively *K. apion* and *K. ara*. The essential difference between the two subgenera is ascribed to the difference in "the shape of the posterior limb" which for *K. apion* is described as being "long, sharp-pointed, backswept, triangular" and for *K. ara* "stubby, rounded" (Shaw, idem).

In the writer's supplementary description of *Kingstonia apion*, it was noted that the "posterolateral limbs of the cranidium vary from shapes that approximate an isosceles triangle where one side is the dorsal furrow, to a right triangle. The former is the 'elongate' type of limb. . . . The latter is the 'short' type of limb. The holotype of *K. apion* had 'elongate' limbs." (Tasch, idem: 295). Thus, in a relatively large sample within the *same* species we get both types of limbs, elongate and short. This suggests that *variation in limb-type within the kingstonids referred to above, is more likely to be a specific rather than a subgeneric character.*

The recent discussion (Shaw, idem) points out that "most other features seem to be somewhat intergrading" (between types of the proposed subgenera) with the exception of the shape of the posterior limbs. As indicated above, considerable variation in shape of the posterior limb is to be expected given a sufficient sample of the same kingstonid species. Hence as presently defined it seems doubtful to the writer that the proposed kingstonid subgenera (*Kingstonia*) and (*Ucebia*) provide a distinction sufficiently discriminatory.

Kobayashi in describing the subfamily Kingstoniinae substituted a discussion for diagnostic features. Shaw (idem) adds a brief descripion but diagnostic features are still not available. Accordingly, these are given here.

Cranidia ranging in general outline from hemispherical to subquadrate and trapezoidal; convexity of glabella variable between uniform and low, to high-angled, both longitudinally and in a vertical direction. Frontal lobe of uniform width or prolonged anteriorly along a line drawn vertically through the glabella. Rim may or may not be present, with or without striations. Dorsal furrows parallel glabella on either side and usually show slight tendency to converge anteriorly; faintly defined in smooth, but well-indented in exfoliated specimens. Posterior extremities of fixed cheek may have a lateral elongation (posterior-lateral limbs) which may be considerably produced; where such lateral elongation is present there will be varying degrees of concavity of sides of the fixed cheek in the ocular region corresponding to subquadrate outline, or if absent, the cranidia will have hemispherical outline.

JURASSIC AMMONOIDEA

W. J. ARKELL
Sedgwick Museum, Cambridge, England

1. Family Berraisellidae, Subfamily Neocomitinae

Odontoceras Steuer, 1897, *Steueroceras* Cossmann, 1899, and *Cuyaniceras* Leanza, 1945.

These generic names have been most recently discussed by Spath (1924, p. 88), Breistroffer (1937, p. 19), and Leanza (1945, pp. 52–4). All three discussions contain mis-statements which have confused the issue, and although Prof. Leanza arrives at the correct solution he seems to do so by invalid reasoning. The following are the historical facts, followed by a statement of the nomenclatural consequences.

1897. *Odontoceras* proposed by Steuer (1897, p. 164) for *O. anglicum* St. *O. transgrediens* St., and other species; intended for a group of Tithonian ammonites of Argentina.
1898. Type species *O. anglicum* St. designated by E. Haug (1898, p. 115).
1899. *Steueroceras* proposed by Cossmann (1899 p. 45) as replacement name for *Odontoceras* Steuer on the mistaken assumption that it was invalidated by *Odontocera* Serville, 1834, and *Odonthocera* Rondani, 1861. Nothing said about a type, which automatically becomes the same as that of the nominal genus replaced, i.e. *Odontoceras anglicum* Steuer (Article 30, f).
1910. Discussion by Uhlig (1910, p. 156) who saw the holotype of *O. anglicum* and mentioned that A. Pavlow had identified it with *Aulacostephanus pseudomutabilis* (de Loriol), of the European lower Kimeridge.
1912. Discussion by Burckhardt (1912, pp. 163–164) who illegitimately "proposed to restrict the genus *Steueroceras* Cossmann to the group of *Odontoceras koeneni* Steuer."
1924. Discussion in a footnote by Spath (1924, p. 88) who incorrectly stated 1) that Cossmann had "restricted" *Odontoceras* to *O. transgrediens*, and 2) that the type species "remains" *O. transgrediens*. This species had in fact never been the type and no one had previously suggested that it should be.
1937. Discussion in a footnote by Briestroffer (1937, p. 19) who 1) illegitimately designated *O. koeneni* Steuer genolectotype of *Steueroceras* (but as stated above the type was already *O. anglicum* St.); 2) incorrectly stated that it was Cossmann who had designated *O. anglicum* genolectotype of *Odontoceras* Steuer. Briestroffer's footnote is phrased with such economy of language, however, that I find it impossible to be sure of his meaning. In any case, it adds nothing to the facts, except to point out that *Odontoceras* is a valid name.
1945. Full discussion by Leanza (1945, pp. 52–54), who correctly points out that (as shown by Uhlig in 1910) *Odontoceras anglicum* Steuer is a Kimeridgian *Aulacostephanus* from near Weymouth, England. Leanza therefore concludes that *Odontoceras* Steuer and *Steueroceras* Cossmann are synonyms of *Aulacostephanus* Tornquist, 1896, and he introduces a new generic name *Cuyaniceras* for "the group of *Odontoceras transgrediens* Steuer." (No type mentioned; *transgrediens* now designated lectotype.)

Leanza arrives at this conclusion by a false argument, however, and those not conversant with the history related above might infer that his conclusion is false; for he has apparently overlooked Haug's type designation of 1898. Nevertheless his conclusion is correct, and *Cuyaniceras* is the valid name for the Lower Cretaceous genus of Neocomitinae for which *Odontoceras* and *Steueroceras* were intended, but for which they are precluded from use by Haug's type selection of 1898.

It has been shown (Arkell, 1951, p. 188) that by strict interpretation of the Rules the genus *Aulacostephanus* Tornquist, 1896, must be interpreted by *Ammonites mutabilis* Sowerby, and therefore that *Rasenia* Salfeld, 1913, is a synonym, but application has been made to have *A. mutabilis* d'Orbigny non Sowerby designated type by the Commission under its plenary powers. If this application is not granted, the Kimeridgian *Rasenia* Salfeld will have to be called *Aulacostephanus*, and the Kimeridgian genus *Aulacostephanus* auct., to which *Odontoceras anglicum* Steuer belongs, will have to be called *Odontoceras*, a name introduced for Lower Cretaceous species from Argentina. It will be one of the most outstanding cases of confusion ever resulting from strict application of the rules of Nomenclature.

REFERENCES

ARKELL, W. J., 1951, Bull. Zool. Nomenclature, vol. 2, parts 6/8, pp. 181–190.
BREISTROFFER, M., 1937, C. R. Soc. géol. France, p. 19.
COSSMANN, M., 1899, Rev. crit. Paléozool., iii, p. 45.
HAUG, E., 1898, Rev. crit. Paléozool., ii, p. 115.
LEANZA, A. F., 1945, Anales Mus. La Plata, i, p. 52.
SPATH, L. F., 1924, Geol. Mag., 61, p. 88.
STEUER, A., 1897, Pal. Abh. Jena, vii, p. 164.
UHLIG, V., 1910, Pal. Indica (15), iv, p. 156.

2. "*Perisphinctes dacquéi*"

Paleontologists having the worthy object of doing honour to the distinguished German paleontologist Edgar Dacqué would do well in future to avoid naming species of *Perisphinctes* after him. This has been done four times already:

1. *Perisphinctes dacquéi* Steiger, 1914, Pal. Indica (15) vol. 4, fasc. 5, p. 475, pl. 102, figs. 1, 2, from the Spiti Shales. It appears to be an *Aulacosphinctoides*.
2. "*Proplanulites*" *dacquéi* Krenkel, 1915, Paleontographica, vol. 61, p. 247; and see explanation of pl. 23, footnote, where it is said to be a *Perisphinctes*. The type specimen (pl. 23, fig. 8) seems to be a *Choffatia*. The horizon is the Callovian of Lithuania.
3. "*Planites*" *dacquéi* Spath, 1925, Collection of Fossils & Rocks from Somaliland, Mon. Hunt. Mus. Univ. Glasgow, p. 122. The type specimen is *Perisphinctes virguloides* (non Waagen) Dacqué, 1914, from the Upper Oxfordian of Abyssinia. It is not a "*Planites*" and not Kimeridgian, but is a typical Upper Oxfordian *Perisphinctes* sensu stricto as Dacqué perceived.
4. *Perisphinctes* (*Virgatospinctes*) *dacquéi* Basse, 1930, Mém. Soc. Geol. France, N. S. vol. 6, mém. 14, p. 113, pl. 4, fig. 15, from the Kimeridigan of Abyssinia. The type specimens seem to be not *Virgatosphinctes*, which would imply a Tithonian (Umia) date, but *Subplanites* (*Virgatosphinctoides* or some allied subgenus) of Middle Kimeridgian age.

Under the Rules, nos. 3 and 4 require new specific names.

ADDENDUM TO "*ATRYPA* IN WESTERN AUSTRALIA"

P. J. COLEMAN
University of Sydney, Australia

From the syntypes listed for various species in the article "*Atrypa* in Western Australia" (Jour. Paleontology, vol. 25, pp. 677–690, 1951) the following specimens are here chosen as holotypes:

Atrypa reticularis teicherti, no. 26273c
Atrypa multimoda, no. 26645d
Atrypa desquamata kimberleyensis, no. 26247a
Atrypa aspera prideri, no. 26126l
Atrypa parva, no. 26294a

The remaining syntypes of each species therefore become paratypes. Repository of the types is the Geology Department, University of Western Australia.

Corrigenda for this same article include:

1) Delete 26553b and 26550c from the list of types given for *Atrypa multimoda*, p. 682.

2) In Table 1, for *A. multimoda* read *A. reticularis teicherti*, and vice versa.

3) In figure 2, for *A. multimoda* read *A. reticularis teicherti*.

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, P. 862–863, SEPTEMBER 1952

REVIEWS

GEOLOGIC GUIDEBOOK OF THE SAN FRANCISCO BAY COUNTIES by 28 authors. California Division of Mines, Bull. 154, 392 pp., 300 figs. $2.50.

Yerba Buena, a delicate ground vine from which may be brewed a pungent tea, gave its name to the early San Francisco. Around "The City" and the nearby counties centers a spectacular history of both mankind and the ever-changing earth. It is of this region that the guidebook is written in a series of 32 articles, grouped into seven principal parts plus an index and a helpful glossary of geologic terms.

The first part, "Historical Background" describes discovery and settlement by Spaniards, English and Russians, together with a well-illustrated section on the Indians of the area, their shell mounds, weapons and stone implements. To this are added two descriptions written by white men in the last century, describing the techniques of arrowhead manufacture.

Part II, "History of the Landscape," sets forth the immediate history of the present topography and reviews conditions which are changing the region today.

Two of the four chapters in Part III, "Geologic History" depict clearly the overall picture of the land-building processes and conditions of the area. The section by Taliaferro gives a detailed account of the geologic formations, their history and characteristics, using maps, drawings and airphotos. That by Bowen and Crippen consists of a series of geologic maps covering all 12 counties, accompanied by a short article explaining the criteria of classification, map symbols and the problems of condensing the maps to the scale used.

Part IV, "Prehistoric Life," impresses upon the reader the youth of the region and the need for more extensive exploration in its paleontology. The section on ancient forests is most enlightening, as it relates the former plant life to that of the southern part of the continent pictures of present southern forests being related to photographs of fossilized leaves from the Bay Area.

Part V treats the minerals of the region, beginning with a general account of the industrially important varieties and processes for their production and preparation. Remaining articles deal with building stones, cement, salt, fuels, diatomite, serpentines, and the history of the New Almaden quicksilver mines.

Part VI contains one article on the past and present water supply.

Three articles comprise part VII "Places to go and Routes to Travel." Combined historical and geological road logs are given for several of the main highway routes from San Francisco. Lists of the unusual minerals in each of the 12 counties are appended.

This interesting guidebook will be useful to the layman and the geologist, to the old-timer as well as the visitor. The articles vary in degree of technicality, thus providing for general as well as detailed study. Perhaps for the clear comprehension of the layman the order in which some of the sections are presented might be altered, and the inclusion of a table giving all the divisions of geologic history would aid in giving perspective to the relative youthfulness of the Bay Area. The excellent selection of maps, photographs and drawings are a real help in understanding and enjoyment of the region, and give one a real insight into its fascinating history.

MARTHA HAYNE

GRUNDLAGEN DER BIOSTRATONOMIE by Arno Hermann Müller. Abhandl. Deutsch. Akad. Wissensch. Berlin, Kl. f. Math. u. allg. Naturw., Jahrg. 1950, no. 3, 1951, 147 pp., 79 figs., 26 tables.

Biostratonomy, established, after earlier attempts by Joh. Walther, by J. Weigelt as a special discipline within Dollo's and Abel's paleobiology and greatly advanced since by contributions from Weigelt, R. Richter, and many others, is defined as the science dealing with the relations in site between fossil and sediment and between the fossils among each other. Thus it investigates all processes acting on the dying animal, the corpse, or its parts capable of preservation.

It may be said to cover, to a certain extent, the field to which our National Research Council applies, in the title of one of its publications, the designation "Marine Ecology as Related to Paleontology."

In presenting this science, the author builds up a strictly methodical framework which he then fills in with the observations of many students pertaining to this subject. Although he includes the results of his own research, this book is essentially a careful compilation of previous work. The bibliography lists close to 400 titles, but the total of papers utilized by the author must be markedly higher, since not so few among those referred to in the text cannot be found in the bibliography. Obviously owing to the scientific separation of Germany from the western world during the recent war, studies of German and Austrian authors predominate by far among those quoted, and American students will look in vain for important British, American, and other western contributions to this field of knowledge.

The German usage that evolved during the last two decades, especially the replacement of familiar terms of Greek or Latin origin by more or less artificial and cumbersome German ones (e.g., "*autonom*" by "*eigengesetzlich*"), and the use of a considerable number of ad hoc created technical terms make this book rather difficult reading even for a person mastering the German language. As examples of such technical terms R. Richter's "*Einregelung*," "*Einkippung*," and "*Einsteuerung*" might be quoted from among many others. All three concern the orientation of fossils in the sediment, the first representing the general term, the second indicating "*Einregelung*" by rotation around a more or less horizontal axis, and the third that by rotation around a vertical one. Profuse use of such terms gives even more cause for regret that the paper lacks an index.

Notwithstanding the preceding comments, this book is a true storehouse of information on the subject and may well prove most valuable as a reference work also to students other than German.

OTTO HAAS

ON THE FISH-LIKE TAIL IN THE ICHTHYOSTEGID STEGOCEPHALIANS, by Erik Jarvik. Meddelelser om Grønland, Bd. 114, nr. 12, pp. 1–90, 36 text figs., 21 folding plates. København, 1952.

Discovery of amphibian remains in the Upper Devonian of east Greenland was announced in 1933 by the late Dr. Gunnar Säve-Söderbergh. Only the skulls were described at that time; these were shown to be extremely fish-like in the proportions of the skull roof, position of the nasal openings, and retention of vestiges of the opercular bones. Now striking evidence of the intermediate position of the ichthyostegids between crossopterygian fishes and amphibians is afforded by new material showing the tail which bears a small median fin supported by endoskeletal radials and dermal fin rays.

Perhaps even more interesting to students of vertebrate structure are the illustrations of ichthyostegid vertebrae, pelvis, and hind limb. The vertebrae consist of neural arch, interdorsal ossification, and ventral arch, all very similar to those of the crossopterygian *Eusthenopteron*. Each half of the pelvis is a single large plate-like ossificationl meeting the other plate in a long ventra, symphysis, and giving off a posterior dorsal process like that of other primitive amphibians. The hind limb and foot are fully tetrapod in structure, similar to *Trematops*, and will be described in detail later.

Further information on skull structure of the ichthyostegids is given, and the account makes possible for the first time a reconstruction of these extremely interesting animals. The fine illustrations amply support the author's conclusion that the Devonian ichthyostegids were indeed the oldest amphibians.

JOSEPH T. GREGORY

JOURNAL OF PALEONTOLOGY, VOL. 26, NO. 5, P. 864, SEPTEMBER 1952

SOCIETY RECORDS AND ACTIVITIES

NOMINATIONS FOR MEMBERSHIP

In accordance with Article 3, Chapter 1, of the By-Laws of the Paleontological Society, the Secretary submits the following nominations for membership in the Society. The list has been approved by Council.

ALLIATA, ENRICO DI NAPOLI, Instituto di Geologia, Università di Milano, Via Boticelli 23, Milano, Italy. K. E. Caster, E. N. K. Waering.

BARLOW, JAMES A., JR., 1300 Custer St., Laramie, Wyo. A. B. Shaw, S. H. Knight, H. D. Thomas.

BEST, EDWARD WILLSON, Science Hall, University of Wisconsin, Madison, Wis. L. M. Cline, M. L. Thompson, L. R. Laudon.

BLYTHE, JACK GORDON, 514 Sooner Dr., Apt. 4, Norman, Okla G. A. Huffman, C. C. Branson, R. W Harris.

BROWNE, RUTH GILLESPIE, 3809 Warner Ave., Louisville, Ky. G. D. Harris, K. E. Caster, F. D. Holland, Jr.

CRANE, FRANK, 4612 Calmont Ave., Ft. Worth 7, Tex. R. L. Casanova, K. E. Caster.

CUMMING, LESLIE MERRILL, Science Hall, University of Wisconsin, Madison, Wis. L. M. Cline, M. L. Thompson, L. R. Laudon.

DESIO, ARDITO, Instituto di Geologia, Università di Milano, Via Boticelli 23, Milano, Italy. Julia A. Gardner, K. E. Caster, E. N. K. Waering.

DIXON, JAMES WILLIAM, JR., Dept. of Geology, Baylor University, Waco, Tex. L. M. Cline, M. L. Thompson, L. R. Laudon.

FRANKEL, LARRY, 136 S. 29th St., Lincoln, Neb. B. H. Burma, T. M. Stout.

HILL, ROBT. BURETTE, Rt. 1, Cisco, Tex. G. G. Huffman, R. W. Harris, C. C. Branson.

HOARE, RICHARD DAVIS, 444-K St., Columbia, Mo. A. G. Unklesbay, R. E. Peck.

HOLMQUEST, HAROLD J., 826 N. Elmwood Ave., Oak Park, Ill. W. A. Kelly, B. F. Howell.

JACKSON, ROBT L., P.O. Box 6, Vernal, Utah. K. G. Brill, Jr., K. E. Caster, E. N. K. Waering.

JENKINS, FLOYD ALBERT, S.J., 221 N. Grand Blvd., St. Louis, Mo. K. G. Brill, Jr., K. E. Caster, E. N. K. Waering.

KASKA, HAROLD V., Dept. of Geology, University of Indiana, Bloomington, Ind. F. M. Swartz, J. J. Galloway.

KERSTING, CECIL C., 3722 E. Apple St., Muskegon, Mich. R. V. Kesling, C. W. Hibbard, G. M. Ehlers.

MARTIN, WARD ROBT., 907 Webster St., Ottawa, Ill. R. L. Langenheim, Jr., K. G. Brill, Jr.

MCCOY, MELVILLE RILEY, 1509 Cascade Ave., Boulder, Colo. A. B. Shaw, S. H. Knight, H. D. Thomas.

NORDENG, STEPHAN CARL, Dept. of Geology, Science Hall, University of Wisconsin, Madison, Wis. L. M. Cline, M. L. Thompson, L. R. Laudon.

OLIVER, WILLIAM A., JR., Dept. of Geology, Cornell University, Ithaca, N. Y. J. W. Wells, W. S. Cole.

OXLEY, PHILIP, Geology Department, Hamilton College, Clinton, N. Y. K. E. Caster, E. N. K. Waering, F. D. Holland, Jr.

PERSON, RICHARD ABEL, 5202 Glendale St., Duluth 4, Minn. R. L. Heller, K. E. Caster, F. D. Holland, Jr.

LEONARDI, PIERO, Instituto di Geologia, Università di Ferrara, Via Boldoni 14, Ferrara, Italy. K. E. Caster, Julia A. Gardner, E. N. K. Waering.

POLLOCK, CHARLES A., 11233 70th St., Edmonton, Alta., Canada. R. W. Harris, G. G. Huffman.

LA RIVERS, IRA, Biology Dept., University of Nevada, Reno, Nev. A. S. Warthin, Jr., E. R. Larson.

SCHMIDT, HERTA, Senckenberg Museum, Senckenberg-Anlage 25, Frankfurt a.M, Germany. K. E. Caster, F. D. Holland, Jr., E. N. K. Waering.

STEVENS, JOE TRAVIS, 500 S.W. 3rd St., Marietta Okla. R. D. Alexander, Jr., C. E. Decker, G. G. Huffman.

WILLIAMS, RODNEY KING, Box 846, South Bend, Wash. E. M. Baldwin, L. F. Daugherty.

WOODWARD, HAROLD W., Geology Dept., University of Wisconsin, Madison, Wis. L. M. Cline, M. L. Thompson, L. R. Laudon.

Announcing—

Available through college bookstores and geology departments

INDEX SPECIES OF GULF COAST FORAMINIFERA

A Student Set of Stratigraphic Foraminifera—Designed and compiled from results of a survey made among teachers of micropaleontology and from studies of correlation charts published in leading geologic and paleontological publications, including those specially devoted to the petroleum industry.

This set includes both guide species and those considered essential to the understanding of stratigraphic micropaleontology.

200 cards, covering 147 species, with descriptive text and full illustrations,
Edition limited to 100 sets Price per set—$12.50

For information concerning this set and regular units of the McLean Card Catalogue of American Foraminifera, please write to:

James D. McLean, Jr., P.O. Box 916, Alexandria, Virginia, U.S.A.

DISTRIBUTION OF EVOLUTIONARY EXPLOSIONS IN GEOLOGIC TIME

A Symposium

LLOYD G. HENBEST, *Editor*, and 17 others.

Published in the Journal of Paleontology, May, 1952.

Paper-bound copies of this 98 page symposium may be secured from the Secretary of the Paleontological Society, Dr. K. E. Caster, University of Cincinnati, Cincinnati 21, Ohio. Postpaid price (remittance with order) $2.00 per copy, or $1.75 each in lots of five or more.

OFFICERS OF THE SOCIETIES

THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

For the year ending March 1953

President, C. C. CHURCH, San Francisco, Calif.

First Past-President, T. H. PHILPOTT, Shreveport, La.

Second Past-President, W. C. KRUMBEIN, Evanston, Ill.

Vice-President, M. B. STEPHENSON, Houston, Tex.

Secretary-Treasurer, C. G. LALICKER, Lawrence, Kan.

Editors

GROVER E. MURRAY and L. J. WILBERT, JR.; Baton Rouge, La., for paleontology.

W. H. TWENHOFEL, Orlando, Fla. (consulting editor) for mineralogy.

JACK L. HOUGH, Urbana, Ill. (editor) for mineralogy.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

For the year ending March 1953

President, M. J. DAVIS, Houston, Tex.

Past-President, FRANK A. MORGAN, Los Angeles, Calif.

Vice-President, J. G. BARTRAM, Tulsa, Okla.

Secretary-Treasurer, John W. Clark, Dallas, Texas.

Editor, KENNETH K. LANDES, Ann Arbor, Mich.

THE PALEONTOLOGICAL SOCIETY

For the year ending November 1952

President, JULIA A. GARDNER, Washington, D. C.

Vice-President, HOLLIS D. HEDBERG, Summit, N. J.

Secretary, KENNETH E. CASTER, Cincinnati, O.

Treasurer, FRANK M. SWARTZ, State College, Pa.

Editor, A. SCOTT WARTHIN, JR. Poughkeepsie, N. Y.

Chairman, Pacific Coast Section, Merton Y. Williams, Vancouver, B. C., Canada.

Ex-Presidents

WINIFRED GOLDRING, Albany, N. Y., 1949.
CHARLES E. WEAVER, Seattle, Wash., 1950.
HAROLD E. VOKES, Baltimore, Md., 1951.

JOINT COMMITTEE ON ZOOLOGICAL NOMENCLATURE FOR PALEONTOLOGY IN AMERICA

Sponsored by the Society of Economic Paleontologists and Mineralogists, The Paleontological Society, and the Society of Vertebrate Paleontology in support of the International Commission on Zoological Nomenclature.

Policy Board

G. WINSTON SINCLAIR, *Chairman* (PS)
R. C. MOORE (PS), BRYAN PATTERSON (SVP)

Members

D. L. FRIZZELL A. MYRA KEEN KATHERINE V. W. PALMER BRYAN PATTERSON	1950–1952
RAYMOND C. MOORE J. BROOKES KNIGHT G. WINSTON SINCLAIR JOHN W. WELLS	1951–1953
S. W. MULLER J. B. REESIDE, JR. BOBB SCHAEFER J. M. WELLER	1952–1954

Address all communications to the chairman, G. WINSTON SINCLAIR, University of Michigan, Ann Arbor, Mich.

THE GEOLOGICAL SOCIETY OF AMERICA

For the year ending November 1952

President, THOMAS S. LOVERING, Denver, Colo.

Vice-Presidents: WENDELL P. WOODRING, CARL O. DUNBAR, HAROLD E. VOKES, ADOLF PABST

Secretary, H. R. ALDRICH, New York, N. Y.

Treasurer, J. EDWARD HOFFMEISTER, Rochester, N. Y.

Councillors

E. F. DAVIS J. HOOVER MACKIN RICHARD J. RUSSELL	1950–1952
RONALD K. DE FORD THEODORE A. LINK WARD C. SMITH	1951–1953
GLENN L. JEPSEN PHILIP B. KING HARRISON SCHMITT	1952–1954
IAN CAMPBELL	1952